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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See page 17, Nov. 16. 1134

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TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS
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all Classes of HANDLING MACHINERY.
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The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES,
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

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See's Patent Hydro-Pneumatic **Ash Ejector**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4825

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See Advertisement page 77.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } Row's Patents.
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Unique Opportunity.
FOR SALE,
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New Electric Portal Harbour Cranes,
Capacity 3 tons and 1½ tons,
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Built to a first-class Colonial Specification.
Ready for IMMEDIATE DELIVERY, including spare parts.
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HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

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See Advertisement page 62, Nov. 16. 2402

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See Full Page Advt., page 38, Nov. 9.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See advert., page 82, Nov. 9. 8195

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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E. 15. 1794

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SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
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See our Illustrated Advertisement, Nov. 16.

If It Must Be Light, Make it of Aluminium.
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Founded 1854 by Sir WILLIAM FAIRBAIRN.

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Thousands of boys pass out yearly from our Elementary Schools and the Middle Forms of our Public and Secondary Schools. The Polytechnic Preliminary Technical School, conjointly with the Schools of Architecture and Engineering, provides a COMPLETE COURSE of PREPARATION for boys to enter one of the following as a career:

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Day, Evening or Correspondence Courses of Preparation for all examinations. Thousands of successes during the past eighteen years.—G. P. KNOWLES, M.B.E., B.Sc., A.M.I.C.E., etc., 39, Victoria Street, Westminster, S.W.1. C 188

TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, Invite

Tenders for :—

1. Lead Sheets...	fee	5/-
2. India-Rubber Hose Pipes, Sheets, etc.	,,	5/-
3. Canvases, etc.	,,	5/-
4. Galvanized Sheets...	,,	2/6
5. Brass Sheets, Copper Tubes, etc. ...	,,	10/-
6. Drysalteries...	,,	2/6
7. Ramps	,,	2/6
8. Mild Steel Bars	,,	£1
9. Vertical Boilers	,,	10/-

Tenders are due by Eleven a.m. on 4th December, 1923. Tender forms obtainable at above address. FEES NOT RETURNABLE. C 230

CRANES.

Sealed Tenders will be

Received by the DIRECTOR OF ARMY CONTRACTS until Eleven a.m. on the 4th December, 1923, for the PURCHASE of:—

One 15 ton STEAM LOCOMOTIVE JIB CRANE, 32 ft. Jib, Boiler by Spencer Hopwood. Makers, Ransome & Rapier.

One 15 ton STEAM LOCOMOTIVE JIB CRANE, with Pile Driving attachment, 30ft. Swan neck Jib, Boiler by Spencer Hopwood.

Pile Driver 30 cwt. Southgate Steam Monkey, can be drawn up 14 ft. 6 in. Makers, Craven Bros. Ltd.

Forms of Tender, Conditions of Contract and any further particulars may be obtained on application to the DIRECTOR OF ARMY CONTRACTS (D.C. Sales), Imperial House, Tothill Street, Westminster, S.W.1. C 226

To ELECTRICAL ENGINEERS.

The METROPOLITAN ASYLUMS BOARD invite separate

Tenders for Alterations and

EXTENSIONS to the INSTALLATION of ELECTRIC LIGHTING and POWER in the New Kitchen at Tooting Bec Mental Hospital, Tooting, S.W. 17, in accordance with Specification and Drawing prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawing and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m., on Wednesday, 21st November, 1923, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona-fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing have been returned.

Tenders, addressed as noted on the form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, 5th December, 1923.

(By Order) G. A. POWELL,
Clerk to the Board. C 208

TYNE IMPROVEMENT COMMISSION.

CONSTRUCTION OF TIMBER JETTY IN HOWDON YARD BAY.

THE TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Construction

of a TIMBER JETTY at their Howdon Yard.

Copies of the Form of Tender, Conditions of Contract, Specification and Drawing may be obtained on application to the undersigned on payment of a deposit of £2 2s, which will be returned on receipt of a *bona fide* Tender.

Tenders, in sealed envelopes, endorsed on the cover "Tender for Timber Jetty," must be addressed to the General Manager and delivered to him not later than Noon on Monday, the 10th day of December, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne,
20th November, 1923. C 193

TYNE IMPROVEMENT COMMISSION.

LOCOMOTIVE SHED AT ALBERT EDWARD DOCK, NORTH SHIELDS.

THE TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Construction

of a STEEL SHED for Locomotives at their Albert Edward Dock, North Shields.

Copies of the Form of Tender, Conditions of Contract, Specification and Drawings may be obtained on application to the undersigned on payment of a deposit of Two Guineas, which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes, endorsed on the cover "Tender for Locomotive Shed," must be delivered at the undermentioned offices, addressed "The General Manager, Tyne Improvement Commission," not later than Saturday, the 1st December, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Newcastle-upon-Tyne,
21st November, 1923. C 232

TYNE IMPROVEMENT COMMISSION.

ELECTRIC MOTORS AND ACCESSORIES.

THE TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Construction

and DELIVERY of 13 SETS of D.C. ELECTRIC MOTORS and ACCESSORIES, about 42 H.P. each, with Worm Reduction for driving Dock Gate Winches.

Copies of the Form of Tender, Conditions of Contract, Specification and Drawing may be obtained on application to the undersigned, on payment of a deposit of One Guinea, which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes, endorsed on the cover "Tender for Electric Motors and Accessories," must be delivered at the undermentioned Offices addressed "The General Manager, Tyne Improvement Commission," not later than Saturday, the 1st December, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Newcastle-upon-Tyne.
21st November, 1923. C 233

TYNE IMPROVEMENT COMMISSION.

SINGLE SCREW STEAM STEEL MOORINGS VESSELS.

THE TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Construction

and DELIVERY of a SINGLE SCREW STEAM STEEL MOORINGS VESSEL, to be used for drawing and fixing mooring screws in the bed of the River Tyne and for salvage work, of the following approximate dimensions:—

Length overall - - 113 ft. 4 in.
Length between perpendiculars - 105 ft. 0 in.
Breadth moulded - 30 ft. 0 in.
Depth moulded - 11 ft. 6 in.

Vessel to have a speed of seven knots.

Copies of the Form of Tender, Conditions of Contract, General Specification and Outline Drawing may be obtained on application to the undersigned on payment of a deposit of £2 2 which will be returned on receipt of a *bona fide* Tender.

Tenders must be sent to the undermentioned Offices under cover addressed to "The Chairman, Dredging and River Works Committee" and endorsed "Tender for Moorings Vessel" not later than Noon on Monday, the 10th day of December, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne,
20th November, 1923. C 194

PORT OF BRISTOL.

CONSTRUCTION OF EASTERN ARM, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction

of the EASTERN ARM of the ROYAL EDWARD DOCK, AVONMOUTH.

The work will consist principally of the removal and carrying to spoil of the main excavation for the arm of the Dock, together with the construction of a ferro-concrete built Wharf about 1700 ft. long on each side. Also the construction of two three-floor ferro-concrete built Transit Sheds, each 500 ft. long; and a ferro-concrete built Silo Granary of about 6000 tons capacity.

On and after Monday the 26th inst. copies of the Specification and Contract Drawing can be obtained from the undersigned on the production of a receipt showing that a deposit of £15 has been paid to the Docks Committee at 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £15 will be returned to all *bona fide* tenderers after the receipt of a tender accompanied by all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Construction of Eastern Arm, Royal Edward Dock, Avonmouth," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m. on Monday, the 7th day of January, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE,
Chief Engineer,
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks,
20th November, 1923. C 224

LONDON AND NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for the Construction

of the STEEL SUPERSTRUCTURE of a BRIDGE to carry the Pontop and South Shields Branch over a new road through the Deans in course of construction by the Borough of Shields.

The Contract comprises the Supply and Erection of the whole of the Steelwork (about 49 tons), etc.

Drawings and Specification may be seen and detailed quantities and Form of Tender obtained on personal application at the Office of the Chief Engineer, North Eastern Area, York. Sealed Tenders, marked, "Tender for Deans Road Bridge, Pontop and South Shields Branch" must be received by the Joint Secretaries, London and North Eastern Railway, Marylebone Station, London, N.W.1, by Nine a.m., November 29th, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

JAMES MOLAREN,
G. F. THURSTON,
Joint Secretaries.

Marylebone Station,
13th November, 1923. C 191

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Tenders for Piping, Valves,

PUMPS, etc., Required in connection with Abbey Mills Pumping Station, Abbey Lane, Stratford, London, E.15.

Persons desiring to submit Tenders may obtain the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, Charing Cross, S.W.1, upon payment of the sum of £5. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council, at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 10th December, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. C 223

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON.

NOTICE IS HEREBY GIVEN that the Senate will proceed to

Elect External Examiners as

follows:—
For the Calendar Year 1924.

ELECTRICAL TECHNOLOGY.
ENGINEERING MATHEMATICS.

N.B.—Attention is drawn to the provision of Statute 124, whereby the Senate is required, if practicable, to appoint at least one Examiner who is not a Teacher of the University.

Application form and particulars of the remuneration and duties can be obtained from the External Registrar.

Candidates must send in their names to the External Registrar, GEO. F. GOODCHILD, M.A., B.Sc., with any attestation of their qualifications they may think desirable, not later than Wednesday, 5th December, 1923. (Envelopes should be marked "Examinership.")

The Senate desire that no application of any kind be made to individual members.

If testimonials are submitted, one copy of each is required. In no case should original testimonials be submitted. The appointments in Engineering will be made by the Senate in January. Applicants who desire that the result should be communicated to them are requested to enclose a stamped and addressed envelope with their applications.

E. C. PERRY,
Principal Officer.

University of London,
South Kensington,
S.W.7.
November, 1923. C 204

CAPE TECHNICAL COLLEGE. CAPE TOWN.

Applications are Invited for

SENIOR LECTURER in Electrical Engineering. Salary £450—25—650.

Applications, which will be received up to the 10th December, 1923, must be accompanied by certified copies of testimonials of works and teaching experience and should state age of applicant.

The holder of this post will be required to join the Government Provident Fund and must contribute 6 per cent. of his salary.

Two years' probation, subject to six months' notice either side; afterwards, three months' notice.

£50 allowed for travelling expenses, but a proportionate amount of this to be repaid if the contract is terminated in less than two years.

Teaching experience may be taken into consideration when deciding the initial salary.

Apply in first case to Messrs. CHALMERS, GUTHRIE & CO., LTD., 9, Idol Lane, London, E.C. C 225

CIVILIAN EDUCATIONAL STAFF. ROYAL AIR FORCE.

Applications are Invited

for VACANCIES in Grades III and IV to be filled in January, 1924.

Candidates must have served in the War of 1914–1918, and preference will be given to those who have had experience as commissioned officers.

The scales of pay for these grades are now under review, the existing rates being as follows:—

EDUCATION OFFICER, GRADE III.
Scale of Pay: £375 by £15 to £395, by £20 to £580.

EDUCATION OFFICER, GRADE IV.
Scale of Pay: £300 by £15 to £450.

Allowance is made for War Service and for previous experience of a suitable character.

Further particulars and the necessary form of application can be obtained from the SECRETARY, AIR MINISTRY, Adastral House, Kingsway, London, W.C.2. C 207

The Royal Air Force

REQUIRES SKILLED FITTERS General (for training as Aero Engine Fitters), Fitters Driver Petrol, Electrical Fitters and Power Station tradesmen. Age limits:—Ex-Service men 18 to 30; Non-Ex-Service 18 to 26; highly skilled Fitters up to 35. Ex-N.C.O's up to 38 years (with rank according to trade ability). Pay from 24s. 6d. to 66s. 6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call:—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, W.C.2. B 736

Assistant Tank Farm

SUPERINTENDENT REQUIRED for the East, with experience in Tank erection and in the construction of large Tank Farms. Must be of good organizing ability, able to control European staff (erectors) and native labour and carry out work economically. Salary according to qualifications. Three years' Agreement and free passage out and home. Free furnished bachelor quarters but not messing. Age not over 35.

Write, with full particulars and copies of Testimonials, to BOX A, c/o. The Regent Advertising Service Ltd., 4, London Wall Buildings, London, E.C.2. C 131

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive written

Applications from Duly

Qualified Candidates for the undermentioned POSTS to be filled in connection with the Company's Workshops in India.

(A) ASSISTANT STORES SUPERINTENDENT.
(B) ASSISTANT WORKS MANAGER—Relieving.
(C) ASSISTANT TRANSPORTATION SUPERINTENDENT.

TERMS:

The appointments are for Three years under agreement in the first instance, which may be subsequently extended by arrangement. The Company will provide first-class passages to India.

SALARIES:

The salaries of the respective appointments will fall within the following limits:—

Assistant Stores Superintendent—
Rs. 800 to Rs. 1300 per mensem.
Assistant Works Manager—Relieving—
Rs. 600 to Rs. 1150 per mensem.
Assistant Transportation Superintendent—
Rs. 450 to Rs. 1150 per mensem.

The initial salaries will ordinarily be the minimum of the scale notified against class of appointment, but may be higher if specially qualified men are selected. Increases of salary will be in accordance with the incremental scale which may be seen in the Company's Office. Increments are granted after each year of approved service up to the maxima stated above.

Leave will be granted at the discretion of the Company in accordance with the rules. Leave cannot be claimed as a right. The Leave Rules may be seen in the Company's Office.

GENERAL QUALIFICATIONS:

Candidates should be between the ages of 28 and 40 for appointments (A) and (B), and between 25 and 35 for appointment (C), and should have had a first-class education and subsequent training as Mechanical Engineers in Railway or Manufacturing Workshops.

ASSISTANT STORES SUPERINTENDENT. (A)

In addition to having received a Mechanical Engineer's training, the Candidate should be conversant with modern Workshops practice and have a thorough knowledge of Stores organization as applied to Manufacturing and Repair Workshops. The successful Candidate, whilst on the cadre of the Stores Department and remaining under the Chief Stores Superintendent for discipline and methods of procedure, would be attached to the Department of the Chief Mechanical Engineer for service in connection with the Workshop Stores into which he would be required to introduce up-to-date methods of procedure both from the technical and commercial standpoint.

ASSISTANT WORKS MANAGER—RELIEVING. (B)

Should preferably have received his training and held administrative positions in a Railway or Locomotive Builders' Workshops. As relieving officer he would be called on to carry out the duties of the various officers on the Works Manager's cadre on their proceeding on leave and it is therefore desirable that the successful Candidate should have had a very general administrative experience in Engineering Workshops.

ASSISTANT TRANSPORTATION SUPERINTENDENT. (C)

Should have received a regular apprenticeship in Railway or Locomotive Builders' Workshops and had subsequent experience in running shed and footplate work. It is desirable that the Candidate should have some knowledge of telephonic traffic control and should be acquainted with the block system of signalling and the principles of interlocking of points and signals. Preference will be given to Candidates who, in addition to the above, have some electrical knowledge. Candidates should preferably be unmarried.

The selected Candidates would be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Forms upon which applications must be made may be obtained on written request (mentioning particular appointment to be applied for) to Messrs. ROBERT WHITE & PARTNERS, 8, Victoria Street, London, S.W.1, the Consulting Engineers to the Company, and to whom the forms must be returned on completion.

With the application forms will be sent brief particulars of the Railway Provident Fund. C 220

THE SCOTT-STILL ENGINES OF THE MOTOR SHIP "DOLIUS."

WHENEVER a change in the economic production of power has been shown to be obtainable, by the improvement of a well-established type of engine or by the introduction of entirely new means of transforming the heat contents of fuel into useful mechanical energy, the shipbuilders and shipowners of our country have not lacked either imagination in gauging the immediate and future possibilities, or courage in deciding to make successful application of them in actual installations. When pioneer work of this character is undertaken one of the earliest things done is to construct an experimental engine by means of which the original claims may be substantiated and work done in investigating the action of the various components, with a view to further improving the design. Once it can be demonstrated that the results are satisfactory and guaranteed consumptions may be given, the application to actual work follows. The Scott-Still engine has gone through this process, and the development at every stage has been referred to in the columns of ENGINEERING until now, when we illustrate the actual engine installed in a motor ship.

In this type of engine the two-stroke Diesel cycle is performed in the cylinder above the piston, while steam is used as a power producer below the piston. The reason for making this combination of the two types of engine is to keep down the heat losses to a minimum. This is accomplished by generating the steam, that is used in the engine, by utilising waste heat. For this purpose the water which circulates in the cylinder jackets is kept at the working steam pressure. Any heat passing through the cylinder walls is not lost but used to generate steam and thus made available for conversion to mechanical energy. Heat is also recovered from the exhaust gases by means of a regenerator, in which steam is produced, as well as by a feed heater. Early experimental work showed that considerable economies in cost of running could be obtained with this combined oil and steam engine, and the results of a series of tests conducted at the works of the builders, Messrs. Scotts' Shipbuilding and Engineering Company, Limited, of Greenock, before a deputation of engineers from France were given in ENGINEERING, vol. cxii, page 344, while a report by Captain H. Riall Sankey on tests which he conducted on October 5 and 6, 1921, were reprinted by us later (*see* vol. cxiii, page 177). On the basis of this and their own experimental work, and the experience they had gained in the running of the engine, the builders were able to consider the application of the system to actual vessels, and a cargo vessel propelled by the new engines was ordered by Messrs. Alfred Holt and Co., of Liverpool. This vessel, the m.s. Dolius, is now fast approaching completion and, as it is the first in which a large-scale installation of Scott-Still engines has been fitted, the details of the power plant are of quite exceptional interest. The starboard engine is shown on the test bed in Fig. 1, and at the left may be seen the experimental engine, on which the work was done which gave the information on which the design of the engine was based. The drawings of the engine are shown in Figs. 2 to 4, on Plate XXXVII, the general machinery arrangement of the vessel is illustrated in Figs. 5 to 10, on Plate XXXVIII, while sectional views, to a larger scale, of the cylinder are given in Figs. 11 and 12, Plate XXXIX.

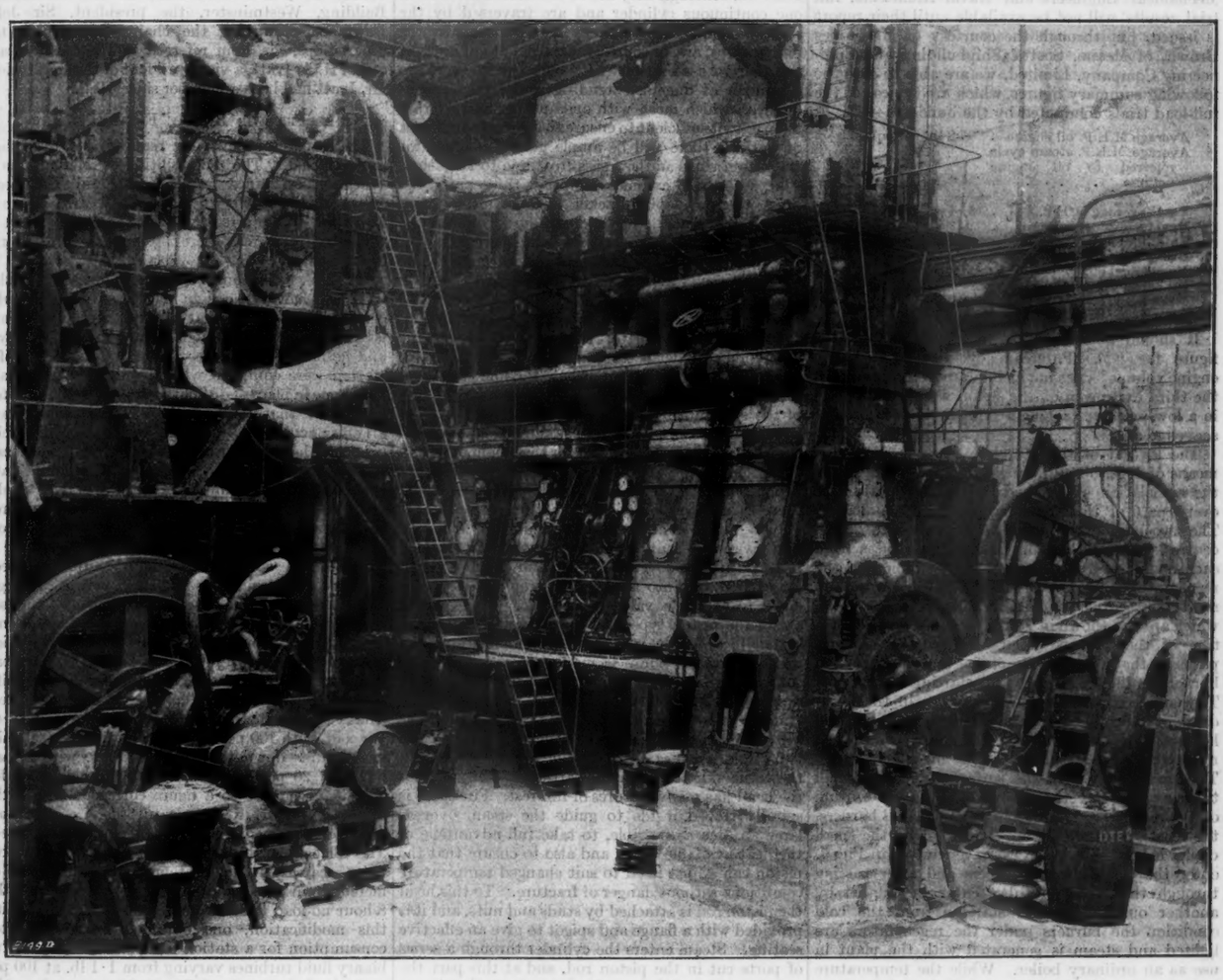


FIG. 1. ENGINE ON TEST BED.

The m.s. Dolius is 400 ft. long, 52 ft. moulded breadth, 32 ft. moulded depth, and has a displacement of 11,650 tons on a draught of 25 ft. 6 in. Everything in connection with the ship and its machinery was constructed in accordance with the requirements of Lloyd's Register of Shipping and the British Corporation, and in compliance with the regulations of the Home Office and the Board of Trade. The total power of 2,500 b.h.p. is divided between two main engines of four cylinders, each 22 in. diameter and 36 in. stroke. At this power the engines are conservatively rated and run at between 115 r.p.m. to 120 r.p.m., giving a ship speed of about 11 knots when fully loaded under service conditions. The steam is generated at about 140 lb. per sq. in. pressure, and is first employed at the back of the piston in one cylinder acting as a high-pressure one, and then is taken to the other three, which, together, act as the low-pressure cylinder.

The general arrangement and details of the design of the engine may be seen in Figs. 2 to 4, on Plate XXXVII. The cylinders are supported on simple A-shaped frames. The guides are of the double slipper type, but split and have one-half carried by each column of the frame. This construction was adopted to permit the use of the special type of crosshead, which will be referred to later, and allows ready access to the engine from both back and front. Easy removal of the steam cylinder cover, that is the bottom one, is also facilitated by this type of design. It should also be noted that the steam cylinder is supported from the columns quite independently of the cylinder of the oil engine and that there is complete freedom for expansion. The way in which the cylinders are associated will be described in

greater detail in reference to the later illustrations, which are drawn to a more suitable scale. The piston rod crosshead admits the full use of the diameter and length of the pin in transmitting the downward load due to the combustion of the oil. On the upper side the pin is secured to a saddle, which takes the half bearings, through which the upward steam load is transmitted. This saddle is bossed and gives provision for the attachment of the complete crosshead to the piston rod by a cotter. The design is clearly shown in Figs. 2 and 3, while Fig. 4 indicates the method of attachment of the slippers.

In consideration of the fact that official trials of the engines were made by the Marine Oil Engine Trials Committee appointed by the Institutions of Mechanical Engineers and Naval Architects, full trial results will not be available until their report is issued, but through the courtesy of Mr. James Brown, of Messrs. Scotts' Shipbuilding and Engineering Company, Limited, we are able to give the following summary figures, which are typical of the full-load trials conducted by the builders :—

Average M.E.P. oil engine	77·8	lb. per sq. in.
Average M.E.P. steam cycle referred to oil engine volume	6·6	" "
Total average M.E.P.	84·4	" "
Revolutions per minute	122	
Total indicated horse power	1,425	
Brake horse power	1,261	
Mechanical efficiency	87·8	per cent.
Oil consumption per B.H.P. per hour	0·356	lb.
Steam evaporated per hour	2,400	lb.

It should be noted that in the above table the figure for "M.E.P. steam cycle referred to oil engine volume" does not include any consideration of the third expansion of the steam which takes place in a low pressure turbine driving a blower for the scavenge air.

The lay-out of the complete plant is shown by means of Figs. 5 to 10, on Plate XXXVIII. From the association of these six views the location of every part of the machinery is clearly indicated. The two engines are installed to each side of the centre line of the vessel. The exhaust gases from each engine are carried upwards by piping to the regenerators, one view of which is shown on the top right-hand corner of Fig. 5. These regenerators, which are also shown in Fig. 7, are simply an adaptation of the Yarrow boiler and provide separate paths for the gases from the engine and those from oil burners, which are used in starting operations. The engine gases pass through tubes in the lower drum of each regenerator and then through the feed heater above and away by the funnel, which they reach at a temperature of a little over 200 deg. F. The feed heater is of the surface type with small tubes and sits directly on top of the top water drum of the regenerator. The gases from the oil burners, the locations of which are indicated by the small circles below the tubes of the regenerators in Fig. 7, enter the combustion chambers and after passing through the banks of tubes enter the funnel by another outlet pipe. In starting from the cold condition the burners under the regenerators are lighted and steam is generated with the plant in use as an ordinary boiler. While the temperature is being raised it should be noted that the engines are being heated up, for the water in the jackets is in communication with that in the regenerator. The engines are first run as steam engines and easy starting is thus possible. When they are once set in motion, the oil engine side of the system may be set in operation at any time. At first the gases are sent through small primary regenerators, but afterwards they are directed along their normal paths through the main ones. When the ship is under way all the steam from the regenerators is obtained by the use of waste heat contained in the exhaust gases, and it is this steam which is used to augment the power of the engines and actually contributes in that way something between 15 per cent. and 20 per cent. of the total power. The whole combination of regenerators and feed-water heaters in addition to fulfilling the function of enabling the extraction of heat from the gases also serves as a very effective silencer. The scavenge air for both engines is supplied by a turbo-blower located on the second deck. This may be seen in Figs. 5, 7 and 9. It is driven by a low-pressure steam turbine using the exhaust from the steam side of the main engines. After its use in the turbine this steam is passed to the condenser. As a standby an electric motor drive is also provided for the blower and is arranged at the side remote from the turbine. The locations of the electric generating plant and the other auxiliaries are shown in Figs. 5 to 10.

Having now dealt with the general principles of operation of the engine and the arrangement of the plant on board m.s. Dolius, it is proposed to describe some of the distinctive features of the design of the cylinder, piston and valve arrangements, which are shown to large scale in Figs. 11 and 12, on Plate XXXIX. In this the engine may be considered as two definite power units, the one steam and the other oil, although they are so associated as to form one continuous cylinder and are traversed by the same piston. The liners, as may be seen in the illustrations, are, of course, separate, but are brought together for association at the ends, where there are a number of fingers, extending round the circumferences, which mesh with one another and overlap to an extent sufficient to ensure that for all conditions of working there will be ample guiding surface for the piston rings as they pass from one to the other. The combustion cylinder comprises three parts, the liner, the enveloping jacket and the belt which houses the scavenging and exhaust connections. All are given effective support from the columns of the frame by four distance pieces, through which long steel bolts are passed and secured to the main jacket casting by heavy nuts. All loads are thus taken by these bolts and transmitted through to the frames and bedplate. The working liner of the oil engine cylinder is secured at the foot and is free to expand towards the top, where the joint takes the form of a stuffing-box. The other component parts of the system are also free to adjust themselves to the conditions produced by changing temperatures. Similarly support is provided for the steam end from the columns and it also has complete freedom for expansion. At the bottom of the steam cylinder there is a cover of deep formation which leaves only a small annular space within the cylinder, but gives sufficient clearance for the skirt of the piston. In this cover the steam and exhaust valves are carried well into the head to keep the clearance down to as low a value as possible. These valves are of the piston type, and have a simple operating system in which the movement of a plunger under oil pressure from a pump is made use of. The oil is supplied at a pressure of 350 to 450 pounds per square inch, and is passed to the valve operating systems in turn through a rotary distributor. The piston has the characteristic deflector form used in two-stroke engines and is made in two parts. Of these the skirt calls for no particular mention, but the head has many features of interest. Firstly, it is spirally ribbed inside to guide the steam over as large an area as possible, to take full advantage of the heat available there, and also to ensure that the piston can adjust itself to suit changed temperature conditions without danger of fracture. To this head the piston rod is attached by studs and nuts, and it is provided with a flange and spigot to give an effective seating. Steam enters the cylinder through a series of ports cut in the piston rod, and at this part the rod is made of larger diameter to maintain its strength. The fuel injection valve is worked automatically under the injection pressure. The pump is cam operated and regular in its action, but the period during which oil is passed into the engine is controlled by a spill valve, which returns the oil to the suction side of the system. This action is controlled by the governor. A delivery pressure of the order of 6,000 lb. per square inch is maintained when working at normal full load.

The completion of this, the first large installation for marine propulsion of this combined engine marks a further step in the advance towards more efficient use of the available heat resources of fuel. In this endeavour the credit must be divided between three parties, and it is a great satisfaction to know that they are all British. The invention of the system is due to Mr. W. J. Still. Messrs. Scotts' Shipbuilding and Engineering Company, Limited, have, as a result of their experimental work, been able to adopt the system to marine propulsion and to design and construct these engines to stipulated guarantee conditions. The third party, Messrs. Alfred Holt and Co., of Liverpool, were convinced of the value and significance of the work done by the great shipbuilding and engineering firm of Scott's and showed their confidence by ordering this vessel to be fitted with the new engines. The m.s. Dolius will go to sea with the best wishes of all who appreciate a combination of British inventive ability, engineering resource and business enterprise in an endeavour to gain increased economy in marine propulsion.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A MEETING of the above Institution was held on Friday last, the 16th inst., at the Institution Building, Westminster, the president, Sir John Dewrance, occupying the chair. In opening the proceedings, Sir John referred to the recent death of Mr. H. A. Ivatt, a vice-president of the Institution. Mr. Ivatt had been a member since 1887.

MERCURY FOR BINARY FLUID TURBINES.

The paper set down for reading and discussion was entitled "The Possibilities of Mercury as a Working Substance for Binary Fluid Turbines." It was read in abstract by the author, Mr. William J. Kearton. We reprint this paper in another part of this issue, and may here proceed at once to the discussion.

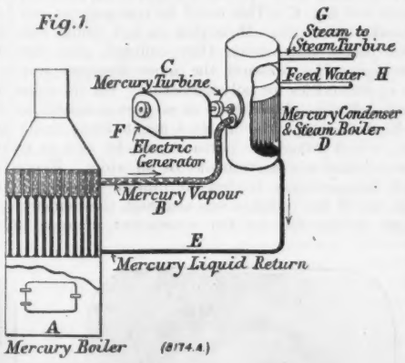
Mr. I. V. Robinson, the first speaker, said that his attention has been caught by the author's remark: "It does not follow that a high thermal efficiency is synonymous with high commercial efficiency," and he had attempted to figure out the saving if a station were equipped with turbines of the binary fluid type in place of ordinary turbines. Mr. Kearton had shown that a binary fluid turbine should have an efficiency of 32·3 per cent. But the commercial efficiency had to take account of the no-load losses of the power station. Many members would have seen the detailed examination of the operating results of the Blackburn Power Station which had appeared in ENGINEERING on October 26, in which the coal consumption, steam evaporation, and output in units for 84 consecutive 8-hour shifts had been analysed and equations given, covering, amongst other things, coal and output. The system used was, he believed, that introduced by his friend, Mr. R. H. Parsons, and showed that in a station equipped with two 10,000-kw. sets the no-load coal consumption was 18,600 lb. per 8-hour shift, with an addition of 1·54 lb. for every unit generated. That yielded a thermal efficiency varying from 17·45 per cent. with 100 per cent. load factor—80,000 units in 8 hours—down to 11·45 per cent. with a load factor of 20 per cent. Converting the 1·54 lb. for the steam turbine to a figure corresponding to the efficiency of Mr. Kearton's turbine, *i.e.*, 32·3 per cent., one obtained 0·96 lb. of coal per unit generated. The Blackburn station was based on 10,000 kw. units, scarcely to be contemplated in the case of mercury turbines, and he suggested reducing the 8-hour no-load losses from 18,000 to 12,000. With this modification, one obtained an overall coal consumption for a station equipped with 5,000 kw. binary fluid turbines varying from 1·1 lb. at 100 per cent. load factor to 1·74 at 20 per cent.; the efficiencies were 27·84 per cent. at 100 per cent. load factor and 18·08 per cent. at 20 per cent. load factor. Working out and comparing these figures, it would be found that, whatever the load factor, the binary fluid turbine would save about three-eighths of the coal of the steam turbines. That was the saving, but what of the other side?

From the current *Electrical Times* he had taken figures relating to the Stepney Power Station. At that station the cost of coal was 0·51*d.* per unit generated, while all other items amounted to 0·45*d.*, or a total of 0·96*d.* per unit generated. The capital charges were 0·5*d.* per unit, making a total cost of 1·46*d.* By saving three-eighths of the coal the amount saved would be 0·19*d.* per unit. Extra capital charges would be incurred, however. He had assumed that the capital charges could be divided, 40 per cent. relating to the generating plant and the other 60 per cent. relating to items which would not be affected, whatever the type of prime mover. As to the extra cost of that plant, he had assumed 25 per cent., but felt that he had

been generous to the binary fluid turbine in so doing, as he did not consider that the arrangement of plant shown in the paper could really be supplied within 25 per cent. of the cost of an ordinary steam turbine. As a set-off against the fuel saving of say 0·2*d.* per unit the other items of works costs would be increased by at least 20 per cent., as the plant would need more labour and attention. The actual figure of 0·45*d.* for these items would therefore be increased by 0·09*d.*, giving a net saving on works costs of about one-tenth of a penny. If the generating plant were 25 per cent. more expensive, without counting the extra depreciation referred to by the author, the increase in capital charges would be 0·05*d.*, so that the net gain in total generating costs would be about one-twentieth of a penny.

The whole object of getting more efficient plant was to save fuel, but no one would be persuaded to make efforts in this direction if only a fractional amount would be saved. He did not consider that the binary fluid system could be regarded as a commercial proposition for a long time, nor did he think Mr. Kearton had suggested that it would be.

Fig. 1.



All schemes which had eventually proved a commercial success had to pass through a preliminary stage, in which the enthusiast had to bear the burden. The saving of ¼*d.*—the figure he suggested if the price of coal was doubled, as he expected would be the case before the binary fluid turbine became a practical success—was not attractive. In one year the Stepney Corporation, had reduced their cost by practically a halfpenny, or from 1·42*d.* to 0·96*d.*; they could not do that every year, but they had done it for one year.

Mr. W. H. Patchell stated that a fortnight ago he was looking at the mercury turbine which the author referred to in his paper. The first mercury turbine was made before the war; and had been partly tested in Schenectady and then left until further opportunity offered to complete the work. It was a small machine made in the works of the General Electric Company at Schenectady. Mr. Emmet had taken the matter about as far as he could on a research basis. He then got in touch with the Hartford Electric Light Company. Mr. Samuel Ferguson, the President of that company, was always looking for something fresh, and Mr. Sorren, his colleague, was equally keen. They agreed with the General Electric to test out a turbine if they would make one. He knew that the author had promised to read a paper on the subject, but hoped it would have been read later in the session when he would have been able to get further details relating to the matter. No figures for publication were as yet available in connection with the Hartford turbine. He was however, able to show some illustrations of the machine.

Mr. Patchell then showed a number of lantern slides of the Hartford turbine which we reproduce on the present page and page 642. Fig. 1 is a diagram of the arrangement. The furnace actually indicated ought to be replaced by a system of oil burners. The mercury vapour passed through the upper space in the boiler, and was superheated, passing then to a single wheel turbine. The vapour then went on from the turbine into the steam boiler, which was the mercury condenser. The steam was then taken over the top of the boiler and turned into the steam main of the Hartford plant. The mercury dropped when condensed and ran back by gravity through a mercury economiser, which was not shown in the diagram, and back into the mercury boiler, so that it was worked in a closed circuit.

A general view of the plant is given in Fig. 2. It occupied the same space as that taken by a water tube boiler of the ordinary Babcock type of 6,000 sq. ft., or as the Americans called it, a 600 h.p. boiler. It was made of those dimensions for practical purposes in order to obtain an idea of what could be got out of a mercury turbine if it replaced some of the small boilers at present at work in America, turning the steam into the ordinary steam range. Other views of the plant are given in Figs. 3 to 7. The view given in Fig. 3 was looking at the drop tubes of the steam boiler with the turbine removed. Fig. 5 shows the mercury boiler in position before the brick work was filled up underneath it, and Fig. 4 the turbine itself which was a single wheel. The view in Fig. 7 was taken with a camera inverted inside the furnace. The boiler at the bottom side was practically a honeycomb. The tubes were not made, as the author suggested, as mercury tubes; but as fire tubes, and the mercury was in the very narrow space between the hexagonal tubes. The bottom part of the boiler could be best pictured if it were imagined that bees when making a honeycomb instead of making single walls made double walls to the cell. The mercury was in the very narrow spaces. The boiler was made up in little units and then the whole thing was welded together. The view, Fig. 6, was taken looking through at the tubes in the steam boiler which were the condensing tubes for the mercury. The ovals were the nozzles which let the mercury vapour into the turbine wheel. The bottom of the condenser tubes can be seen in this view.

The mercury boiler worked at 35 lb. pressure. A great deal of delay occurred due to the impossibility of getting castings which were mercury tight. Mercury went through castings which nothing else would go through. The machine was started on or about September 7, and it was found that one of the castings, in one of the connections, was not quite tight. A piece of steel was accordingly welded on to the inside. The machine, however, only ran for ten days before the piece got loose. That caused a considerable shut down, and the machine was not started again until a

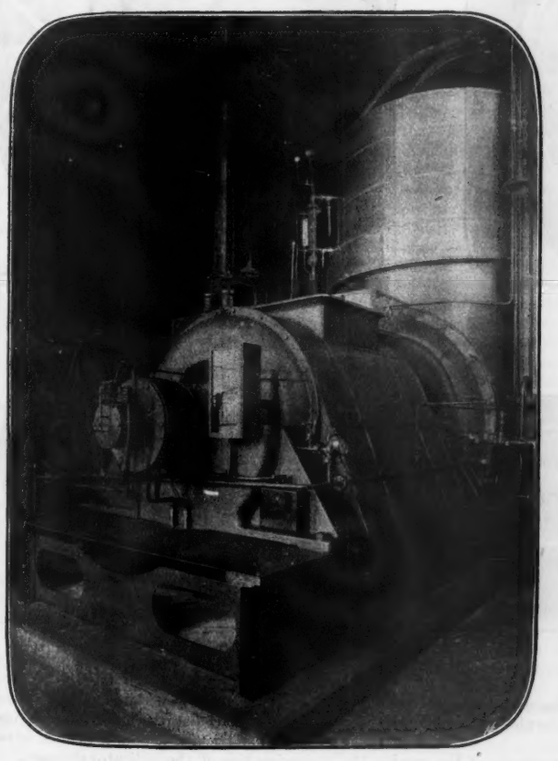


Fig. 2.

Fig. 3.

fortnight ago. Up till that time the machine had run for only 12 or 14 days altogether, although he presumed that since a fortnight ago it had been running satisfactorily. The machine was absolutely quiet and gave no more trouble than an ordinary well-conducted turbine. The alternator, which was of 1,800 kilowatts, had not been driven hard as yet, but they had obtained 1,500 kw. out of the turbine. The steam evaporated by the condensation of the mercury, which did 1,500 kw., measuring from the water pumped into the boiler, was 28,000 lb. Dividing by 14, which was the average water rate of the station, the steam then did 2,000 kw., so that 3,500 kw. had been obtained out of a position which could be occupied by a 600 h.p. boiler.

The temperature due to the pressure of 35 lb. was 800 deg. F.; the temperature picked up by the mercury in going through the superheater was about 50 deg. F., making 850 deg. F. for the mercury vapour. Ordinary steel was absolutely useless at this temperature and different kinds of special steels had been tried. He saw the blades of the turbine, and they had just as clean a finish as they had been before the machine started to run at all. If, however, the temperature was not kept up very high with absolute vapour without any trace of what might be called moisture, the mercury then cut the steel just like a sand blast. The temperature of the mercury vapour leaving the turbine was 430 deg. F. at a 28½ in. vacuum. The steam boiler worked at 200 lb. with 100 deg. superheat. The author in one of his diagrams showed a special form of joint. The Americans had not relied on anything of that sort. The job was welded right throughout. Welding was far more common for high-pressure steam jobs in America than in this country. Joints were only made because it was difficult to arrange for the transport of pieces of machinery without them, but if a joint behaved itself it very rarely had to be opened. There was very little trouble in opening a joint which had been welded. They were generally opened with an acetylene jet.

One point in regard to the mercury turbine which had not been raised was whether engineers could be satisfied that the materials which were being used were going to last at those temperatures under the conditions imposed upon them by the mercury at high temperature. He was not at all sure whether mercury at very high temperatures and pressures would not go through when cold mercury would not. Personally, he was not altogether happy at the idea that engineers were going to build a large central station with stuff that was so extraordinarily ticklish. The Americans were getting practical experience on the subject, but at the present time he was not altogether sure that they were on safe ground.

With regard to the author's statement that "Coupled to these undoubted advantages, its high thermal efficiency will probably make it the foremost prime mover for the generation of electric power on a large scale," he could only say he had his doubts. What did the author mean by "a large scale"? A 10,000 kw. machine was a big one in this country. There were 15,000 and 20,000 kilowatt machines, but they had only one 30,000 kw. machine. They had 30,000 40,000, 50,000 and 60,000 kw. machines in America, and he did not think they would ever get a mercury turbine anything approaching those sizes for many years to come, if ever. The figures that the author gave in the early parts of his paper in regard to high pressure steam were not altogether in line with those for which one could get an actual bid at the present time. Bids had actually been made and plants were on order for high-pressure steam, and the figures quoted by the author were not quite as sanguine as those offered by the actual builders, which had been accepted by the purchasers. Some of the high-pressure steam plants had not yet commenced running. Plants of 300 lb. and 400 lb. were running; a 600 lb. plant would be running shortly; 800 lb. boilers are on order in this country; and a 1,200 lb. plant would be running to his knowledge before very long on the other side. Right up that scale there were at present no definite figures, but as far as they had gone there was pretty strong confirmation that the machines would stand up. Whether the fittings would stand up was another matter.

Mr. H. M. Martin said that the author had stated that mercury was polymerised at temperatures above 500 deg. C. This could be true only at considerable pressures. Molecules, in fact, could only form partnerships when they collided, and thus the higher the pressure the more frequent were the opportunities for polymerisation. On the other hand, collisions played little or no part in dissolving such partnerships, the effective agent being radiation, which jerked the partners asunder just as an X-ray jerked an electron out of an atom. Hence high temperatures tended to inhibit polymerisation, but if the pressure was also high the tendency might be masked by the consequent increase in the number of molecular collisions. Presumably at the critical point all the molecules were co-aggregated.

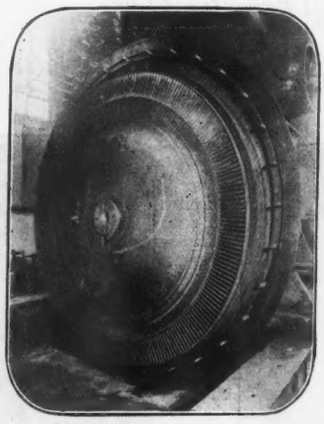


Fig. 4.

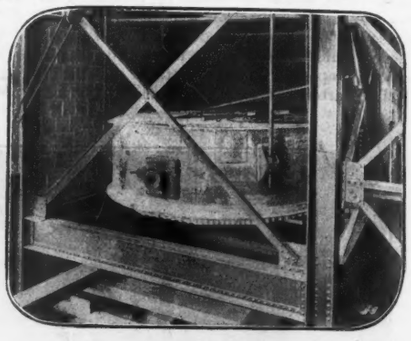


Fig. 5.

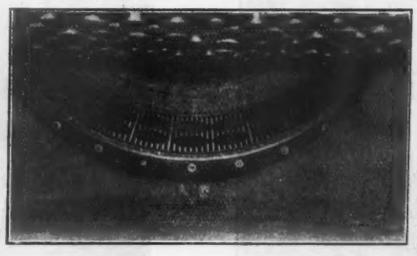


Fig. 6.

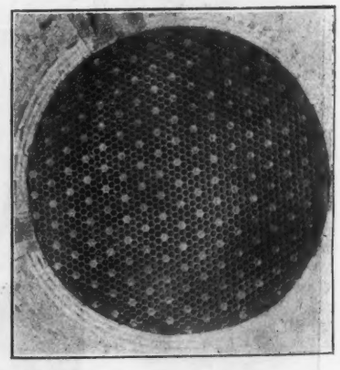


Fig. 7.

The author had based his estimate of the merits of the mercury turbine on the Rankine Cycle, which certainly afforded the most direct and simplest procedure. In the superheated field, however, a comparison on that basis did less than justice to mercury vapour, whilst in the saturated field the method overestimated the relative advantages of mercury over steam. Carnot's theorem that the efficiency of a reversible heat engine was independent of the nature of the working agent must not be extended to actual engines and turbines, the efficiency of which was always less than unity. With real turbines the nature of the working agent formed a very important factor in the thermal efficiency attained. Considering, for example, two multi-stage turbines, one operated with superheated mercury and the other with superheated steam. Letting both turbines have the same stage efficiency of, say, 70 per cent., and letting the ratio of the initial to the final pressure be 10 in each case, then the superheated steam would yield in mechanical work 75 per cent. of the work theoretically due from a perfect turbine, whilst a turbine operated with superheated mercury vapour would yield 79 per cent. The gain with the superheated mercury vapour would be seen to be very considerable. The reason for the difference between the two vapours lay in the fact that the energy dissipated in friction at each stage of a compound turbine was returned to the working fluid as heat. The consequence was that the superheated steam or mercury reached each successive stage a little hotter than it would had the preceding stages been friction free.

In general and in broad outline, it might be said that when heat was added to a gas at constant volume, part of it went in increasing the pressure of the gas and part in increasing the pressure with which the molecules would spin. The energy expended in the latter operation added nothing either to the pressure or the volume of the gas. With steam the energy so expended was a large fraction of the total heat energy supplied. Monatomic molecules, however, did not acquire spin, so, in the case of the superheated mercury vapour, the whole of the friction heat was utilised in raising the expansion line of the indicator diagram.

In the saturated field, however, it seemed possible that the advantage was with steam. With neither fluid could an expansion in that field be effected in conditions of thermal equilibrium. No vapour could, in fact, condense unless it had something to condense on. The reason was given by Lord Kelvin many years ago. He pointed out that the surface of a drop of water was in a state of tension, and thus a certain amount of potential energy was stored up in that surface. If the drop were only small enough that store of energy would be more than sufficient to cause its complete evaporation. Hence, no drop could commence on an infinitesimal scale, but must start from some finite nucleus. Mr. C. T. R. Wilson showed, in 1897, that the nuclei on which his vapour condensed were multiple or associated molecules of H_2O. He experimented with steam which was dust free, but he (the speaker) had been able to prove that the same held good with ordinary boiler steam as used in certain very able experiments of Professor Stodola. Experimenting with transparent nozzles, Stodola found that condensation occurred when the pressure was 3·1 to 3·3 times that due to the temperature, which was 95·5 deg. C. Using Wilson's data obtained at −16 deg. C., his (Mr. Martin's) calcula-

tions gave the figure of 3·08 as against the 3·1 to 3·3 observed by Professor Stodola. He might perhaps add that in a letter received from him last June, Professor Stodola accepted that calculation as establishing what he called the interesting fact, that the nuclei were the same in his (Stodola's) experiments, made with very rapidly moving steam, as in Wilson's experiments made with quiescent steam. That result showed conclusively that such dust particles as might be entrained in ordinary boiler steam played no effective part in promoting condensation. Hence in a steam turbine, condensation did not occur until the temperature had fallen some 30 deg. C. below that corresponding to the pressure and then the excess moisture, or part of it, separated out as a very fine mist. Wilson found, however, that when the expansion was carried beyond the supersaturation limit the droplets could not cool quickly enough to serve as centres for further condensation, so that the steam remained supersaturated till the very end of the expansion. That was what occurred in actual turbines, and the fact involved a considerable reduction in the efficiency ratio obtainable with the L.P. end. In view of the fact that the surface tension of mercury was about eight times that of water, and that its latent heat was much less than that of steam, the supersaturation loss would, he suspected, be much greater than it was with steam, and might more than offset any gain due to a higher reheat factor. From the foregoing remarks it would be evident that a higher efficiency ratio was possible with the "superheated" section of a turbine than with the L.P. end; this was true. In practice, however, the H.P. end had quite commonly a low efficiency, but the reason for that was financial not technical. It was merely a matter of greatly increasing the number of stages in that section, so as to reduce to insignificance the rotation and leakage losses, whilst at the same time securing the most favourable ratio of blade speed to steam speed. There was no secret or patent involved, and if station engineers were prepared to pay the cost they would find any number of firms ready to supply them.

Mr. Max Konig said that a good many firms had considered the problem of the mercury turbine very carefully in the light of the optimistic figures published by Mr. Emmet, in which an improvement of 45 per cent. over steam plant was anticipated. Some years ago, when a member of the staff of a well-known Swiss firm, he had to deal with the problem. After careful investigation the firm came to the conclusion that the figures anticipated by the General Electric Company were too optimistic, and that the overall improvement was not convincing enough to balance the complication of a binary fluid turbine with one component of an acutely poisonous character.

Those investigations were based on a mercury vapour pressure of 28·46 lb. absolute, superheated to 788 deg. F. with a back pressure of 1·16 lb. Steam was produced of 256 lb. absolute at 402 deg. F. and superheated to 572 deg. F. The vacuum of the turbine was 0·57 lb. absolute. One pound of steam was generated by 8·3 lb. of mercury (as against 9·3 lb. given by the author), the work done by the latter being 57 per cent. of that done by the water. Assuming efficiencies of 70 per cent. in the mercury turbine, 75 per cent. in the steam turbine and 85 per cent. in the boiler, the total thermal efficiency of plant appeared to be 27 per cent., as against 32·3 per cent. given in one case by the author. The pressure drop between the boiler and the turbine was assumed to be 4·3 lb. and the temperature drop 36 deg. Prof. Stodola himself expressed the opinion that in comparison with what might be done with pure steam that efficiency was rather disappointing, bearing in mind the extraordinary complication demanded. For comparison purposes he might draw attention to Stodola's investigation on possible overall efficiencies of turbine plants based on a steam temperature of 350 deg. F. at boiler pressures of 315 lb., 471 lb., 628 lb. and 1,570 lb. With 80 per cent. boiler efficiency and 80 per cent. turbine efficiency, the thermal efficiency would be 23·3 per cent., 24·6 per cent., 25·4 per cent. and 27·5 per cent. Furthermore, if a multiple-stage reheating of the feed water gave an improvement of 7½ per cent., the figures would be 25·3 per cent., 26·4 per cent., 27·3 per cent. and 29·6 per cent.

To give another illustration, taking as a basis a cycle such as was proposed to be used by the English Electric Company in the Benson high-pressure plant being erected at their Rugby works, *i.e.*, using steam of 1,423 lb. at a temperature of 910 deg. F., expanding it down in a high-pressure turbine to 164 lb. first and reheating again to the initial temperature of 910 deg. F. in order to expand finally in the low-pressure turbine down to 0·51 lb., the following figures were obtained. The total heat content of the initial steam would be 1,430 B.Th.U. Assuming an efficiency of 70 per cent. of the high-pressure turbine, which was perhaps a little optimistic, including the gearing, and assuming an efficiency of the low-pressure turbine of 80 per cent. the thermal efficiency of the plant worked out at 28·2 per cent.; and if they accepted Stodola's figure of 7½ per cent., possibly increased by multiple reheating of the feed water, that figure would come to 30·3 per cent. It would thus be seen that even if they assumed as correct the author's figure of 32·3 per cent., the gain over the high-pressure arrangement would be only 7 per cent., or 2 per cent. absolute. It must, of course, be admitted that the overall efficiency of the binary arrangement could be raised a certain amount by superheating the steam and by feed-heating arrangements.

Mr. W. M. Selvey referred to the high efficiency figures of the Diesel engine and some types of gas engine, so appealing to engineers connected with the generation of power. There were, however, difficulties arising from the fact that the fluid used was of the nature of a perfect gas. Such a fluid was far removed from its point of condensation at ordinary atmospheric pressures; therefore its density was very small and the amount of work done per pound of working fluid was small, with the result that, for a given output, the engine would be large and heavy. The condensing properties of steam were not sufficiently appreciated; not only did steam condense at or about atmospheric temperature, with an extraordinarily good vacuum, but it had, at the same time, the most exceptional heat capacity, specific and latent. That quality made it an eminently suitable fluid in the practical engine. Engineers had, for many years, contemplated some other fluid which would be condensible at atmospheric temperatures, but which might be able to work at higher initial temperatures than steam. Of all the various fluids suggested mercury vapour had peculiar advantages.

The author showed that there were, roughly, 52 B.Th.U. available per pound of working fluid in the case of mercury, a figure which was extraordinarily low. Concurrently with that, the fluid possessed great density, the figure being 13 or thereabouts. As a consequence, the mechanical dimensions of the turbine were very similar in the cases of both mercury and steam, with the additional advantage—due to the much greater vapour density—of lower expansion velocities; a single wheel sufficed to take up the 52 B.Th.U. per pound of working fluid, with a very high utilisation of material. That was not all, however. It was quite easy to extract the heat by a system of expansion, but much more difficult to put the heat in. The great benefit of a working fluid approximating to, say, oxygen or air, was the ease with which heat could be put into it; it was greatly more difficult to do this with steam, and yet more so with mercury, at all events with the efficiency of 80 per cent. assumed in the author's calculation.

Referring to the difficulty of materials, he did not believe that steam pipe makers in this country would care, in the case of a large installation at high pressure, to go far beyond a temperature of 750 deg. F. The conditions of materials for temperatures round about 750 deg. F. were becoming reasonably well known, and were not such as to encourage engineers to experiment with much higher temperatures. The little mercury boiler which had been shown was not an attempt to make an efficient boiler, but simply a convenient receiver in which to warm up the mercury with an oil jet, which required to be diluted with four or five times excess air. It was impossible to imagine materials that would stand 800 deg. F. on the one side with, say, gases at 2,500 deg. F. on the other side; the gases of combustion from the oil must be diluted. There was a way of meeting the difficulty by placing the mercury heating surface in a particular part of the boiler, provided one could be satisfied that the material used for the mercury heating surface would stand the fire maintained, say, at 50 deg. above the temperature of the working fluid. That involved a reversal of the process of the Still engine, which did a lot of work on air and only a small proportion on steam. The practical solution desired would give a lot of work on steam and not so much on the mercury.

Mr. W. J. Kearton, replying to the discussion, stated that he had attempted to work out the cost of a station, allowing for the various factors involved. He had adopted the figures given in the paper by Mr. Baumann, read before the Institution of Electrical Engineers, in 1921.* He had assumed, in the mercury system, an initial pressure of 35 lb. gauge, with a superheat of 100 deg. F., giving a total temperature of 912·3 deg. F. The mercury turbine had to be of the double-flow type, in order that the mean diameter should be equal to that of the steam turbine. A suitable intermediate steam pressure for such conditions would be 135 lb. per square inch absolute, about 120 lb. gauge and the steam would be superheated to 200 deg. F. Assuming a total capacity of 100,000 kw., the mercury turbines would develop about 49,300 kw., and the rest would, of course, be that developed by the steam turbines. With regard to thermal efficiency, he assumed the same turbine efficiency and boiler efficiency as in the paper. With these figures the overall turbine efficiency ran out at 29·8 per cent. The thermal efficiency of the corresponding steam station (taken from Mr. Baumann's paper) was 21·75 per cent.

Mr. Kearton then referred to one or two features affecting the initial cost of the station. In the case of a steam plant producing steam only, the heat supplied per kilowatt hour in the steam boiler was 12,533 B.Th.U. Taking the binary fluid turbine plant and calculating all the various amounts of heat supplied to the feed water in the steam system, &c., he obtained a total of 9,198 B.Th.U., as against 12,533 B.Th.U. in the pure steam plant. The heat transmitted per kilowatt-hour in a mercury condenser was 5,830 B.Th.U. With regard to the steam condenser, taking into account the difference between consumptions in both cases, the heat transmitted—in the case of a pure steam plant—was 1,450 B.Th.U. per kilowatt-hour.

It had been stated by Mr. Emmet that it was found at the installation at Hartford that they could operate with about 7 lb. of mercury per kilowatt total capacity of the plant, but that he hoped to be able to reduce the quantity by 50 per cent. At the present value of 5*s.* per pound of mercury, the cost per kilowatt capacity was 35*s.* In the particular station considered the total cost of the mercury alone would run out at 175,000*l.* He had assumed the cost of plant and buildings as equal, and had taken the cost of boiler-house plant to be directly proportional to the thermal capacity; in the case of the mercury plant this cost would possibly be rather more. He had assumed the steam turbine costs to be directly proportional to the power. In a large station of the kind considered there would be four units developing power. Without further detail, he would say that the cost worked out at 28·1*l.* per kilowatt capacity of the steam power plant and about 29·01*l.* per kilowatt capacity of the binary fluid plant. He believed the allowances he had made to be fairly reasonable.

Sir John Dewrance then closed the proceedings, observing that he would like the author to indicate how he proposed to obtain the necessary supplies of mercury for the enormous stations which were projected in the paper. He then terminated the meeting after announcing that there would be an extra general meeting on Friday, November 30, when the paper on "Clyde Marine Oil Engines," by Professor Mellanby, which had been read at the Glasgow Summer Meeting, would be further discussed, and that the annual dinner of the Institution would take place at the Connaught Rooms, Great Queen-street, London, on December 13.

* See ENGINEERING, vol. cxi, page 435.

CONCRETE MIXER AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY THE RANSOME MACHINERY COMPANY (1920), LIMITED, ENGINEERS, WESTMINSTER.

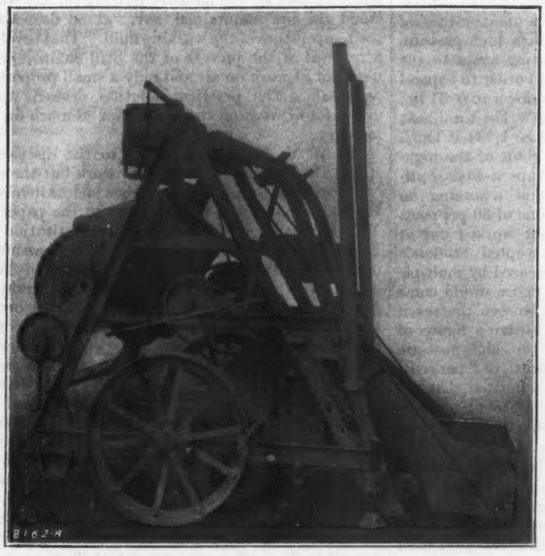
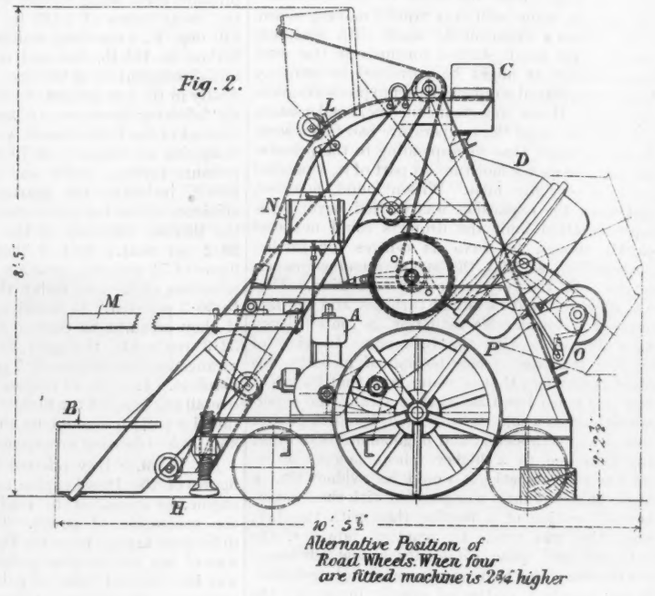
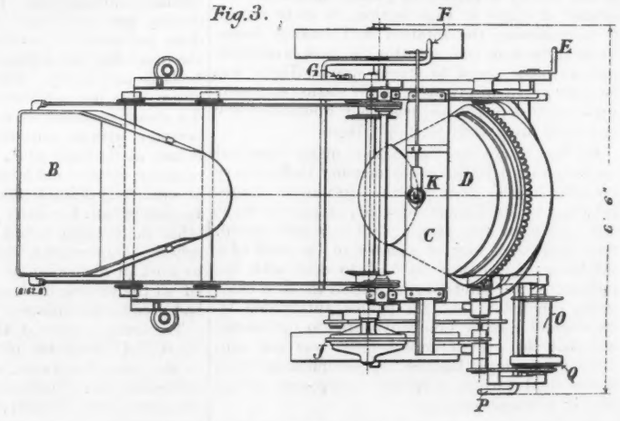


FIG. 1. 5-CUB-FT. LIGHT-WEIGHT CONCRETE MIXER FITTED WITH BARROW HOIST.





THE PUBLIC WORKS, ROADS AND TRANSPORT EXHIBITION.

WITH the large programme of road building and other works undertaken to improve the condition of our national highways, and in some instances advanced so as to mitigate in a degree the pressure of unemployment, a special interest attaches to the Public Works, Roads and Transport Exhibition which opened at the Royal Agricultural Hall, Islington, yesterday. It is argued that recent years have seen a greater advance in road vehicles than in road construction, but the road authorities have always held that they can provide all that is necessary for modern traffic if the cost can be met. We are now in the position of the money being forthcoming, partly as a result of the taxation of motor vehicles, which owners no longer contest in principle though opinions may vary as to the manner of incidence, and partly from other sources, including facilities for assistance by the State with the object, as we have said, of relieving the burden of unemployment.

The use of machinery under such circumstances may be considered to be somewhat anomalous, but modern systems render it imperative. The collection of machinery at the present exhibition is instructive. The exhibition has the advantage in that it appeals directly to the road maker and to the public works bodies in particular. The congress meetings which are held concurrently at the hall attract technical representatives of county and other bodies, and the advantage of getting in touch in this way with the executive officials is, we believe, thoroughly appreciated. A word of commendation may be said of the preparation so well in advance of the delegates descriptive catalogue. This has enabled officials to obtain a very good idea of the value of the exhibition, and has probably decided many of them to make arrangements to visit it.

It is not so much our province to deal with road-making materials as it is with the appliances employed in the work. The exhibits of the former class are numerous and in addition to samples of road metal, asphaltic and bituminous preparations, cement, &c., there are now brought into this field several of the systems of reinforcing concrete by means of wire mesh fabric, and expanded metal and other materials of the lighter kinds. These we need scarcely particularise, as they are already well known to our readers.

As regards machinery the plant divides itself into sections, the chief of which are, perhaps, stone-breaking and preparing machinery, tar macadam plant, concrete plant, rolling and finishing machinery and so on. The exhibits are, of course, mixed, and it is not possible to deal with all in the pages at our disposal, though we shall endeavour to describe those which show novelty or appear to be deserving of special attention in view of the large improvement programmes now in course of execution.

The number of stone-breakers exhibited is perhaps not so great as might have been expected, since these are so necessary to all road work. Messrs. H. R. Marsden, Limited, Soho Foundry, Leeds, are exhibiting one of their latest Blake-Marsden portable machines with a 20-in. × 12-in. mouth. In this machine the jaws are made in halves and can be reversed top to bottom, by which a good deal of economy is effected. Another firm showing stone-breaking machinery is Messrs. Robey and Co., Limited, of Lincoln. The machine in this case is also of the portable type. The mouth of the breaker is 12-in. × 8-in., and the frame is of rolled steel, which is adopted especially with a view to withstanding the severe shocks which occur in working.

The largest number of exhibits of any one type is to be found in the concrete mixers and tar macadam plants exhibited. In this country there is a decided preference for the light-weight concrete mixer as compared with the larger plants in use in America. There, at the present stage, larger jobs are taken in hand at a time, but the small machine is more suitable for being quickly transferred from point to point on the less extensive lengths commonly dealt with here. Some of the small mixers we have dealt with previously, and must refer our readers to the descriptions already given of them in these columns. This applies to the "Roll" concrete mixers shown by the Builders and Contractors Plant, Limited, of 51, Tothill-street, S.W. 1, of which machines we gave a description on page 682 of our issue of June 1 last. These machines are distinguished by a special type of drum consisting of two cups facing each other, and drawn apart for discharging. The "Willing Worker" mixer, a small machine by Mesars Drummond Bros., of Guildford, was also illustrated and described recently in our columns."*

The "Jaeger" mixers exhibited by Messrs. Millar's Timber and Trading Company, Limited, Pinner's Hall, Great Winchester-street, E.C. 2, have also been referred to recently.† These machines have established themselves over here, and though originally imported from the United States, are now constructed by the Millar's Company in this country. The principal features of the machines are perhaps to be found in the drum, the base of which is made of semi-steel, cast with two flats, which it is claimed results in turning the mix right over during the revolution. The upper part of the drum is of steel plate. Split paddles are fitted inside. An automatic water-measuring tank is provided. Overwinding of the hoist is prevented by the clutch being automatically thrown out when the hopper reaches a certain level.

The Ransome Machinery Company (1920), Limited, exhibit one of their light-weight tilting drum concrete mixers with barrow hoist. This machine

* See ENGINEERING, vol. cxv, page 565.
† See ENGINEERING, vol. cxv, page 633.

MACHINERY AT THE PUBLIC WORKS EXHIBITION.

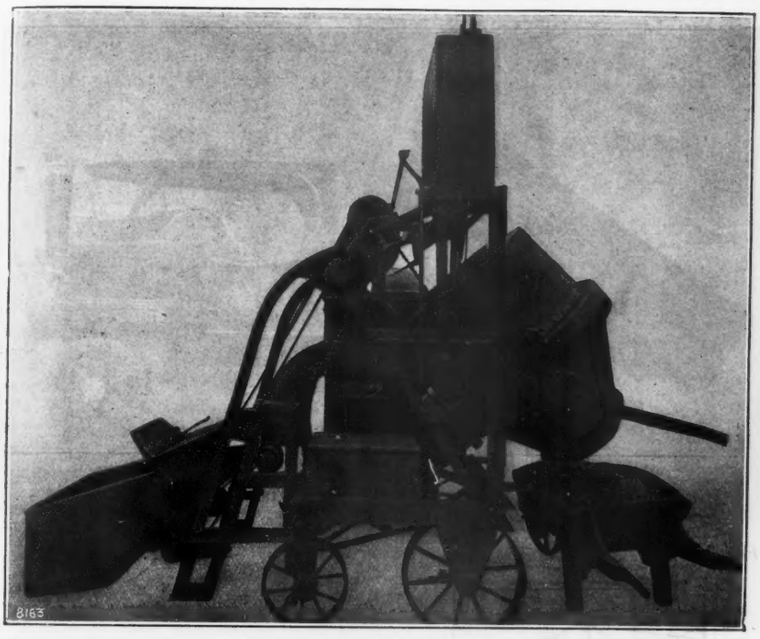


FIG. 4. No. 5 VICTORIA LIGHT-WEIGHT CONCRETE MIXER; MESSRS. STOTHERT AND PITT, LIMITED, BATH.

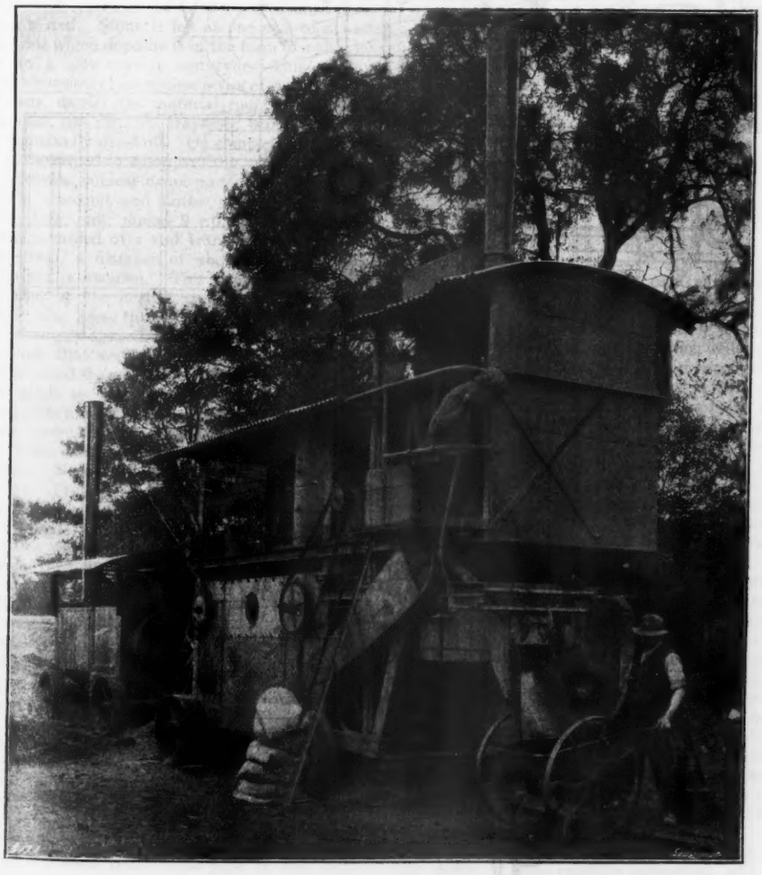


FIG. 5. ASPHALT PREPARING PLANT; MESSRS. JOHNSTON BROTHERS, LONDON.

is mounted on two wheels and is easily run about by two men, making it a very handy appliance. It is illustrated in Figs. 1 to 3, page 644. The capacity of the machine is 7 cub. ft. of unmixed materials, or 5 cub. ft. of mixed batch. The output under favourable conditions is put at 40 batches, equivalent to 7·5 cub. yards of concrete, per hour. The engine runs on petrol and is of 3 h.p., the mixing drum having a speed of 17 r.p.m. The whole machine is arranged in an A frame of channels and angles. At one end of the base blocks are fitted; at the other are two screwed feet which can be pressed down on to any surface to steady the whole when in use. The engine is accommodated on the base and protected by steel plate housing. The drives for the hoist and for the elevator skip are both taken off the main drive for the drum, as will be clear from Fig. 2. The skip serves the purpose as in most of these machines, of both hopper and chute, the elevator being furnished with two sets of rails, by following which the hopper, on being raised high enough, tilts forward and the material discharges into the drum. The drum is carried on a heavy yoke at one end of which is a large sector for tilting. The base of the drum is of semi steel, and cast with a large indentation forming an internal ridge extending across the whole diameter of the bottom. Two sets of spiral blades are also fitted. The machine is chain driven as regards the drive from engine to countershaft, countershaft to mainshaft, and mainshaft to skip hoist-clutch, and main shaft to barrow hoist. The skip is hoisted by wire rope. A cut-out which declutches the drive prevents over winding. A band brake is provided to control lowering out. A special feature of the present model is the small barrow hoist fitted to the framing by the side of the drum, as shown in our figures. This enhances the service of the machine considerably. The barrel is furnished with a ferodo lined clutch, hoisting and lowering being controlled by one lever which is raised to hoist, and depressed to lower out on the brake. The brake band is ferodo lined. The hoist is capable of lifting 3 cwt. at the rate of 130 ft. per minute with a single rope, or 6 cwt. at a speed of 60 ft. per minute using two part tackle. The whole outfit only weighs about 34 cwt.

Fig. 4 illustrates the latest type of small capacity mixer made and shown by Messrs. Stothert and Pitt, Limited, of Orchard-street, Westminster. The machine is capable of dealing with batches of 7 to 7½ cub. ft. of dry materials, making 5 cub. ft. of mixed concrete. In this machine the firm's "Smith" mixer has been considerably modified as regards the drum, which is now made nearly parallel on the charging end and tapered as before on the discharge side. The mixing action of throwing the concrete to and fro across the drum is assisted by blades, and the batch is discharged by tilting the drum by hand. The shape of the drum now adopted has secured an increase in capacity while retaining the advantages of the firm's well-known model of double coned drum. The mixer is carried on a light but rigid frame mounted on four wheels, two of which are arranged in a swivelling fore-carriage. The plant is driven by a 3 h.p. Lister hopper type petrol engine running at slow speed, which results in reduced vibration. The mixer is fed by a skip elevator worked by cable. Water is contained in an 18-gallon tank fitted with indicating gear so that the correct amount can be drawn for each batch.

A new firm to enter this field is Messrs. John Fowler and Co. (Leeds), Limited, who have produced a very neat and workmanlike machine, as will be evident from Figs. 15 to 20, page 654. The size exhibited is known as the 10/7, the first figure indicating the cubic yards of the unmixed materials and the second the volume of the batch. This sized machine has an outside diameter of mixer drum of 3 ft. 6 in. The time of mix is from 40-50 seconds. As will be seen from our illustration the drum is of the non-tilting type, charged from one side which is shown in Fig. 15, and discharged on the other, this being depicted in Fig. 16. The engine, which runs on petrol or paraffin, is mounted on the end of the channel framing, and drives by roller chain on to the main shaft from which the drum is driven by chain. On the main shaft is a reel on to which is wound a wire rope from a reel of

large diameter on a shaft running the length of the drum framing at the top of the machine. This latter shaft is fitted with reels on to which are wound the cables of the hoist. The skip is hinged merely and acts as a chute. On being raised by the winding gear it discharges into the drum. Lifting takes from 5 secs. to 7 secs. The discharge is by means of a hinged scoop controlled by a hand lever. When in the discharging position the mix is thrown on to the scoop as the drum revolves; when out of action the scoop is tilted so that any concrete falling on it is tipped back to the middle of the drum. The drum is carried on four large flanged rollers. The drive is such that the tension of the chain tends to relieve the rollers of part of the load. The mounting is claimed to effect a considerable saving in power. A 5 b.h.p. engine is fitted to the 7 cub. ft. machine. The centre of the drum is of semi-cast steel, the ends being of pressed plate. The interior is fitted with buckets and blades throwing the material in both directions. The main clutch is of the expanding type and can be operated from either side of the machine. The road wheels are of pressed steel of the disc pattern Catches are fitted to hold the front axle rigid when working. The water tank is of the open type fitted with an automatic filling valve, and an automatic register to show the amount of the water in the tank and the amount drawn off for each mix. On account of its level the operator can watch the mix inside the drum. The whole plant is very compact and the same time substantially built.

Other firms showing concrete mixers include Messrs. Gaston, Limited, of Larden-road, Acton Vale, W.3, and Messrs. Frederick Parker, of the Viaduct Works, Catherine-street, Leicester. The latter shows two machines, one of 5 ft. and one of 4 ft. capacity. The smaller machine is shown driven by a 2 h.p. Lister petrol engine and is a self-contained plant. The machines exhibited by Messrs. Gaston, Limited, are the Rex concrete mixers of the Chain Belt Company, Milwaukee, Wis., U.S.A.

Many of the tar macadam drying and mixing plants shown at the exhibition have been previously referred to at length in these columns. For instance, the plant exhibited by Messrs. Stothert and Pitt, Limited, Orchard-street, Westminster, was fully illustrated and described in our issue of June 8 last (p. 683), while one of Messrs. Ransome Machinery Company (1920), Limited, was also dealt with in a similar manner in the same issue. The plant now shown by Messrs. Stothert and Pitt is actually of the portable type. The Ransome plant is characterised by a double drying drum. The Winget tar macadam plant is a large fixed machine and is illustrated at the exhibition by Messrs. Winget, Limited, 24, Grosvenor-gardens, S.W., by means of a model. This plant we described and illustrated in our issue of March 23 last (p. 364). The appliance is provided with a long cylindrical drier feeding a vertical bucket elevator in which the metal is passed through a tar tank, being afterwards allowed to drain before being passed over to a storage hopper for discharge by chute to a wagon. More recently (p. 620 of our issue of last week) we described the novel plant of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, and made at that company's works at Openshaw, Manchester. We need scarcely remind our readers that one of the features of this plant is compactness secured by the adoption of an unusual form of vertical oscillating spiral-fitted drier.

Macadam preparing plant is also shown by several other firms, including Messrs. Builders and Contractors, Limited, who exhibit a small portable plant fitted with an oil burner and intended primarily for the smaller class of work and for repair jobs. Messrs. Millar's Timber and Trading Company, Limited, Great Winchester-street, have at their stand a "Cummer" plant, having an horizontal drum, and in which both binder and aggregate are weighed before mixing, while Messrs. Frederick Parker, Catherine-street, Leicester, show a double tube drying plant and separate trough mixer.

A new type of tar and bitumen macadam preparing plant is shown by Messrs. Johnston Brothers, 79, Mark-lane, London. This is known as the Johnston-Bodman plant. It is of portable design, as illustrated in Fig. 5, page 645, and experience has

STEAM WAGON AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

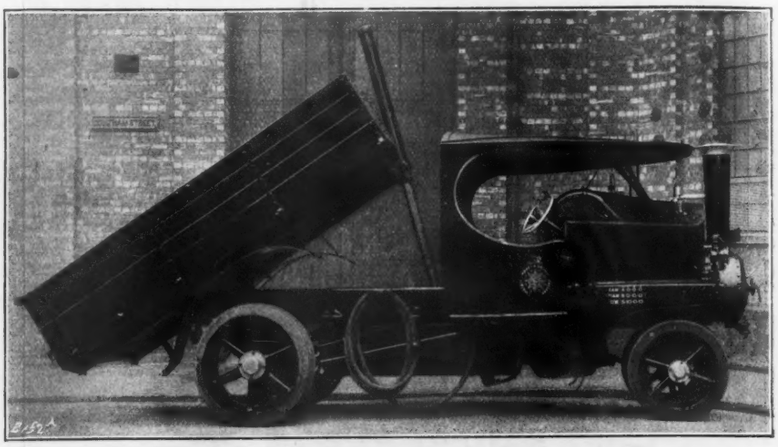


Fig. 6. 6-Ton Steam Wagon with Tipping Body.

Fig. 7.

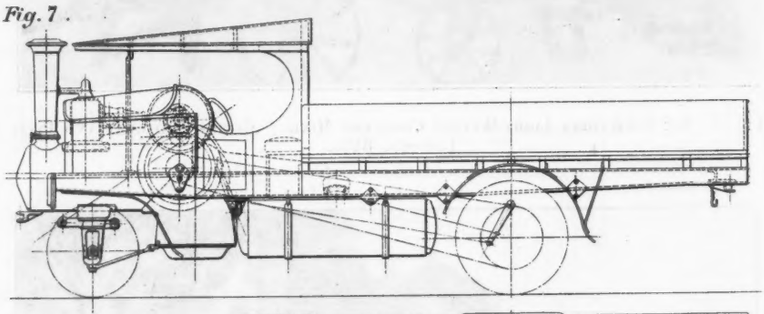
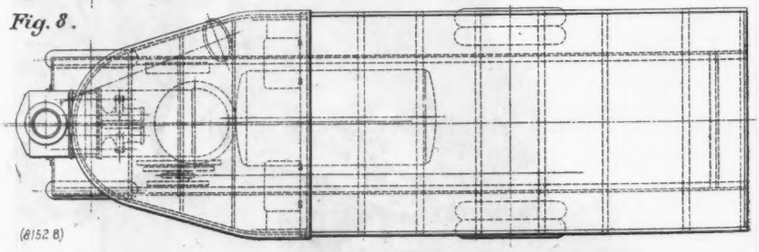
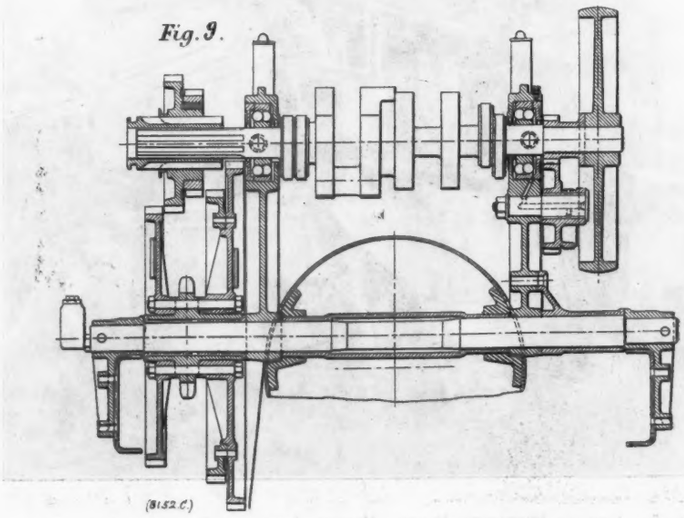


Fig. 8.



(8152 B)

Fig. 9.



(8152 C)

TIPPING GEAR FOR ROAD VEHICLES AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. F. WALTERS AND CO., ENGINEERS, RUGBY.

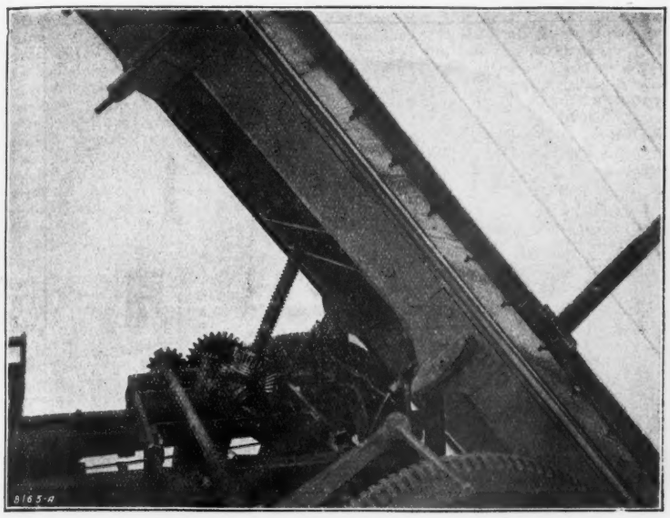


FIG. 10. END TIPPING.

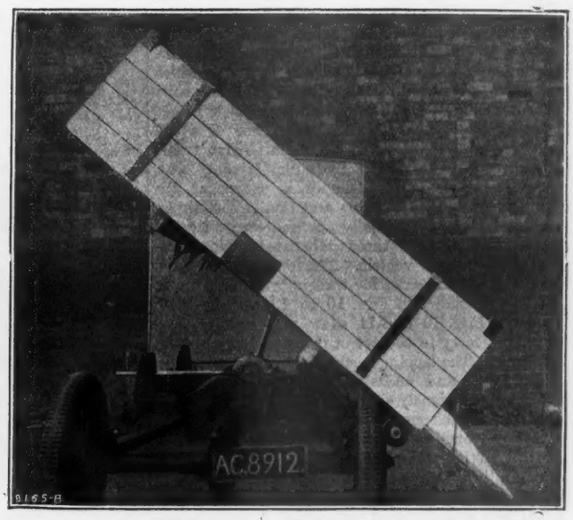
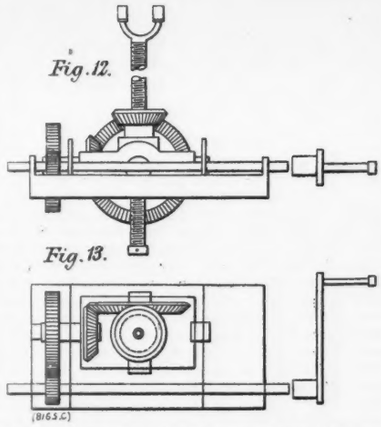


FIG. 11. SIDE TIPPING.

demonstrated that on leaving the works it can be set to work in a very short time. It is operated at full capacity by three men, weighs in all about 9 tons, and is arranged to maintain stone, and deliver it to the hopper, at 250 deg. to 300 deg. F., keeping the supply of tar at 260 deg. or bitumen at 340 deg. F. The movement of all parts is slow, thus reducing wear, noise and the power required. The whole plant is mounted on a chassis covered with a roof. Stone is fed at one end to a bucket elevator which deposits it in the form of a thin layer on to a slow-moving conveyor. This conveyor, which consists of an endless series of small swivelling buckets, carries the material round a combustion chamber, the distance traversed being 16 ft. Here it is gradually dried off. On completing this circuit it is discharged to a hopper from which it is fed into a revolving conical drum provided with angle iron ribs in a second and hotter combustion chamber. This drum only makes 9 r.p.m., and though the metal is turned over and transferred the length of the drum, a distance of about 8 ft., all violent agitation is avoided. This drum is entirely surrounded by the hottest gases from the furnace, which also pass through it, so that the metal is thoroughly heated. The plant is worked on the principle that very high furnace temperatures are not required if ample time of contact is secured, and this tends to economical operation. The furnace has a grate area of 9 sq. ft. and the gases pass through both combustion chambers, containing respectively the drum and conveyor, before leaving by the uptake. Moderate induced draught is arranged for by fan. From the point of discharge from the drum the heated stone or sand is taken by an elevator and stored in a hopper from which it passes to a charge weighing hopper delivering to the tilting type mixer. The tilting mixer delivers at a height of about 5 ft. above the ground at a distance of 4 ft. 6 in. from the side of the machine, so that a cart can be placed well underneath it. The mixer charge is usually 3 cub. ft., and a batch is mixed and discharged in 100 seconds.

With regard to the tar, this is kept in barrels over the combustion chamber where a rack is provided. Tar from the barrels is poured into a small heating tank, a barrel being kept turned over to give a small regular supply. In the tank is a measuring valveless pump which measures off any quantity required for a charge of stone, this amount then being blown by compressed air through the delivery pipe to the mixer, the pipe being cleared completely each time. This pipe is well lagged. The heating tank is placed over the fire-box. The temperature can be regulated by damper. A thermometer is provided, and it is easy to maintain the tar or bitumen at a point which reduces loss, fuming, &c., to a minimum. A hoist is provided for elevating the barrels, and a counter is fitted to the mixer to record the work done. The boiler of the steam plant driving the machine is heated by the same furnace and is carried on the same chassis as the rest of the plant. The plant shown in Fig. 5 is known as a No. 3 asphalt plant and in this the second elevator delivers to a revolving screen supplying grading hoppers. From these measured amounts are fed to a circular non-tilting mixer which is heated by a flue.



FIGS. 12 AND 13. DETAILS OF GEAR CRADLE.

Messrs. Goodwin, Barsby and Co., Limited, St. Margaret's Ironworks, Leicester, also show a drying and mixing plant fitted with a Pyrus cylindrical drier, with dust-removing device, and variable speed drive. This part of the plant is mounted on one carriage, while on a second unit are mounted an engine, tilting open drum mixer, with automatic tar tank and skip power hoist. The drier unit is driven from the mixer unit. Other firms exhibiting this type of plant are Messrs. Thomas Coleman and Sons, Limited, Alfreton-road, Derby, and Messrs. Ord and Maddison, Limited, Darlington, the latter showing a mixer with a capacity of from 10 to 12 tons per hour.

It will be convenient if at this point we deal with some of the exhibits connected with the transport of road material, leaving the machinery suitable for the work of laying it down for a subsequent article. The number of firms exhibiting motor vehicles adaptable to this class of work appears to be fewer than on previous occasions, this being possibly due to the concurrent exhibition at Olympia for commercial vehicles. Doubtless many of the visitors to the Public Works, Roads and Transport Exhibition will also visit the show of commercial vehicles at Olympia.

Among the new models to be seen at the Agricultural Hall, Messrs. Robey and Co., Limited, of Lincoln, are exhibiting a new 6-ton wagon fitted with tipping body. This machine is shown by Figs. 6 to 9, on page 646. Generally speaking, this wagon is built on the lines of the firm's well known 5-ton vehicle, which we described and illustrated some time ago.* The machine is of the over type design with Messrs. Robey's special type of stayless boiler with circular and domed top fire-box formed of pressed steel plates. The boiler of the new machine has larger heating surface than the old, the new model having 91·5 sq. ft. with a grate area of 3·14 sq. ft. The boiler is constructed to work at 250 lb. per square inch, and is tested up to 500 lb. under hydraulic pressure. The working pressure has thus been raised by 25 lb. per square inch. The engine is compounded, the cylinders being 4¼ in. and 7¼ in. in diameter by 7 in. stroke; the cylinders and steam chests are cast together in one. Compared with two speeds in the 5-tonner, the new model has three speeds giving 3, 8 and 12 m.p.h. on normal engine speed, though speeds of 25 m.p.h. are obtainable with the machine. The speed change gear embodies the unusual feature for a steam wagon of a horizontal type of gate change. A section through the crankshaft is given in Fig. 9, which shows the provision of ball bearings for this shaft, in consequence of which engine friction is considerably reduced.

Considerable alteration has been made at the front end of the chassis framing. In the earlier design the side frames were brought in at the front end and riveted direct by flanges to the smoke-box. In the more recent design the side frames are carried straight on, and at the end are riveted to spring plates which, in turn, are bolted to angle irons extending part of the way round the lower half circumference of the smoke-box. The body of the vehicle we now illustrate is 11 ft. long by 6 ft. 6 in. wide and 2 ft. deep. The water tank has a capacity of 140 gallons, and the bunker will take 4 cwts. of fuel. Steel shields are fitted so as to totally enclose the engine. The machine is fitted with cast steel wheels with tubular spokes. The internal expanding brakes act on each of the rear wheels

* See ENGINEERING, vol. cx, page 66.

on a special brake ring bolted to the inside of the wheel, an air space being left between this and the wheel rim so as to avoid the transmission of heat to the tyres. The tipping gear is of the hydraulic type.

The Lacre Motor Car Company, Limited, of 78, York-road, King's Cross, exhibit a 2 to 2½-ton tipping wagon fitted with a 30 h.p. engine, the tipping gear being of the hand operated type which we have previously dealt with. The Yorkshire Patent Steam Wagon Company, of Hunslet, Leeds, have at their stand two machines, one of which is a 6–7-ton vehicle fitted with shaft drive transmission and a three-way hydraulic tipping gear.

An ingenious tipping device is shown at the stand of Messrs. F. Walters and Co., Albert-street, Rugby. This is actually a four-way tipping mechanism, though three only are employed of course on a motor vehicle. The fourth would be of service in special cases for trailers or railway stock. The gear is shown in Figs. 10 to 13 on page 647. Of these, Figs. 10 and 11 show respectively views of a Ford lorry in the act of being tipped end- and side-ways. The tipping mechanism is shown in Figs. 12 and 13, and needs very little explanation as the gear is extremely simple. The lift is secured by means of a jack screw mounted in a cradle which allows universal movement by an arrangement of gimbals, so that the screw can tilt towards whichever direction it is desired to dump the load. In the drawings it will be noticed that the lifting screw is provided with a large bevel nut carried on trunnions in a small cradle. The cradle itself is carried on trunnions in a larger frame, and it will be seen that a bevel is mounted on the axis of each set of trunnions on which lines they can rotate. These two bevels, which mesh with each other, form part of a train of gears transmitting power to the bevel nut of the lifting screw, this train being operated by any suitable combination of reduction gears set as shown in the fixed frame, and worked by a hand crank from either side of the lorry. It will be obvious that the arrangement of trunnions and bevels allows the lifting screw freedom to incline itself as the body is raised, according to which ever direction it is being tipped. The jack bevel nut is provided with a ball bearing. The body is furnished with four bearings which rest on four pillars fitted on the chassis. The body bearings are shrouded by plates which pass over and engage the pins of the chassis bearings. A locking pin in each case passes beneath the latter. When any two of these pins are withdrawn and the screw operated the body tilts on the two opposite bearings.

This wagon is also fitted with ratchet control to the side-boards. The side-boards can be lowered to line with the wagon floor, and there held so that the load is dumped well clear of the wheels. The gear for this includes a spindle, with a small drum at each end, running the length of the body, on each side of the vehicle. At the tail end of the body a small hand ratchet is fitted to each spindle, and attached to the drums are flat link chains carried up over pulleys and fastened at the other end to the side-boards. When ratcheted up, the side-board is drawn up simultaneously at both ends, taut against the body. The ratchet can be reversed for lowering out, when the drums can be slowly unwound and the side-board lowered to any desired amount without fear of the ratchet over-running.

A six-wheeled 5-ton motor vehicle is exhibited at the stand of Messrs. Tuke and Bell, Limited, 27, Lincoln's Inn-fields, W.C.2, and is illustrated in Fig. 14 on this page. This consists of a tractor unit with a two-wheeled body attached by means of a turntable. The engine is a four-cylinder 20 h.p. unit running at 1,000 r.p.m. on paraffin, the cylinders having a bore of 4 in. and stroke of 5 in. The clutch is of the multiple disc type. Three speeds and a reverse are fitted, all shafts being mounted in ball bearings. The 5-ton body is of 100 cub. ft. capacity, measuring 11 ft. by 6 ft. by 1 ft. 3 in. inside. It is fitted with let-down side doors and hand operated end tipping gear, with an automatic tail door as shown in the illustration we give. The internal expanding brake, operated from the driver's seat, can also be controlled from the side of the lorry. The tipping gear enables the whole of the contents to be dumped in 90 secs. in one spot, or they can be spread on the road. The same firm also have on exhibition a 1-ton lorry fitted with end tipping gear, the body having a capacity of 41 cub. ft. This when fitted with covers has a capacity of 100 cub. ft., in which form it is intended for use in connection with house refuse collection, &c.

(To be continued.)

SIX-WHEEL LORRY AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. TUKE AND BELL, LIMITED, LONDON.

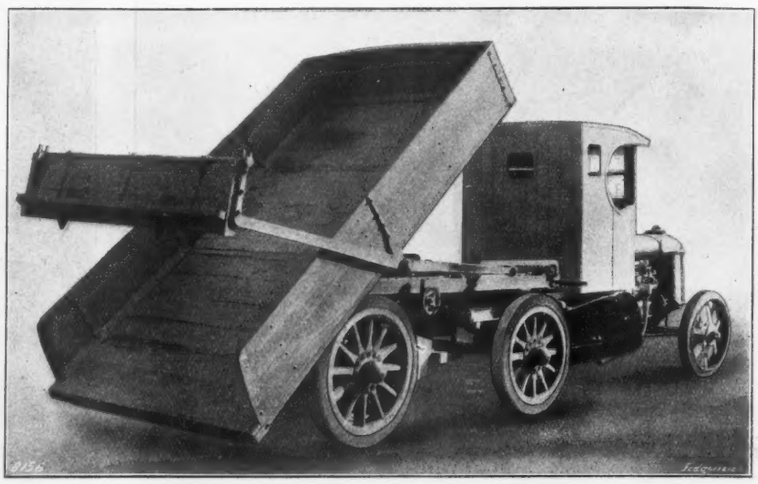


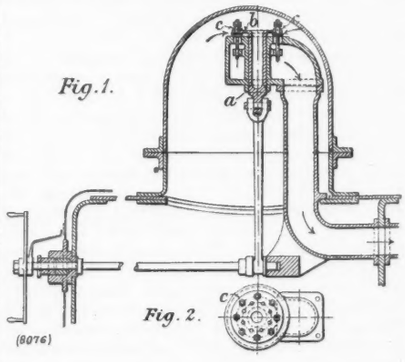
Fig. 14.

MULTIPLE-VALVE LOCOMOTIVE REGULATOR.

The accompanying illustrations show an interesting form of locomotive regulator which has recently been placed upon the market by the Société Franco-Belge de Matériel de Chemins de Fer (S.A.), of La Croyère, Belgium, and is known as the Lejeune regulator. Most of the locomotive regulators in use on British railways are either of the slide valve or balanced-valve types, and troubles are frequently experienced with the former owing to rapid and unequal wear or seizure which render them difficult to control and to maintain in a steam tight condition. With balanced valves, leakage arises from the unequal expansion of the valve and its seating, and the large diameters of the valves, render it difficult for the driver to control the flow of steam so as to avoid jerks and slipping in starting the engine.

The Lejeune regulator, on the other hand, is of the multiple-valve type, and the makers claim that easy starting is obtained with very little effort, and that the valve remains completely steam tight for long periods in service. Other advantages claimed are light wear and tear, easy regulation of the steam in proportion to the load, automatic closing of the valves in the event of breakage of the operating links, and the possibility of admitting a small quantity of steam into the superheater to prevent the formation of scale and the burning of the tubes which are liable to occur when the engine is running with the regulator completely closed; this feature renders the provision of a damper unnecessary.

Of the accompanying engravings, Fig. 1 is a longitudinal section of the complete equipment, Fig. 2 a plan of the valves and Fig. 3 a section of the latter drawn to a larger scale. It will be seen from these illustrations that a cylindrical plunger *a*, having a wide flange *b* formed on its upper end, is fitted into a closed elbow on the end of the steam pipe so that the plunger can slide vertically when the regulating handle is moved. Seated in the upper surface of the closed elbow are eight small mushroom valves lettered *e* in the engravings. These valves, it should be noticed, are not provided with guide wings, with which uneven wear of the seating is sometimes experienced, but are guided by the stems which pass through holes in lugs formed on the closed-elbow casting as is most clearly shown in Fig. 3. The valve stems extend upwards above the valves, passing through clearance holes in the flange, of the plunger, and the upper ends of the stems above the flange are each fitted with a pair of locknuts as shown. In the space between the upper face of the flange and the locknuts, washers *c* are fitted on the valve stems, and the thickness of these washers differs, so that when the plunger is raised by means of the regulator lever, the valves are opened in succession as the washers come into contact with the lock nuts. The first valve has, of course, to be opened against the full boiler pressure, but, as the valve area is small, no great effort is required and the other valves can be opened quite easily as the pressure in the steam pipe becomes higher. A pointer mounted on the regulating lever as shown in Fig. 1, in conjunction with a graduated dial fitted on the back



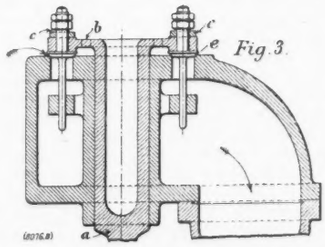


plate of the boiler covering, enables the driver to see at a glance the extent to which the valves are open at any time.

The Lejeune regulator has been fitted to several locomotives of the Belgian State Railways with satisfactory results. It is also suitable for application to steam cranes and other steam-driven machinery which has to be started and stopped frequently or regulated closely while in operation. The patent, it should be mentioned, covers the use of the arrangement described for controlling the flow of other fluids as well as of steam. Messrs. Estler Brothers, South Molton-road, Victoria Docks, London, E., have been appointed agents for the regulator in this country.

INDUSTRIAL NOTES.

A CONFERENCE between the Council of the Mining Association and the Executive of the Miners' Federation was held in London last week-end with a view to consider the proposals made by the Federation for revising the Wages Agreement. Mr. Evan Williams, chairman of the Mining Association, stated that the owners did not see their way to modify the views they had previousiy expressed; he confirmed that they could not agree to a revision of the agreement on the lines which had been proposed. The owners, however, desired that there should be the fullest inquiry into the position, and suggested that a joint sub-committee should be appointed to review the whole situation completely. This suggestion was agreed to by the miners' executive. At the close, the following official statement was made by Mr. Frank Hodges: "A meeting was held to-day (the 15th inst.) between the Executive Committee of the Miners' Federation and the Central Committee of the Mining Association, to consider the application made by the Miners' Federation for amendment of the wages agreement. Mr. Stephen and Mr. Frank Hodges elaborated the claim already submitted in writing to the owners. Mr. Evan Williams said in reply that the owners did not see their way to modify the views they had previously expressed, but proposed that a joint committee should be appointed to review the whole position of the agreement, and to consider both the claims of the Miners' Federation, and also the points which the owners' side wished to put forward. This proposal was accepted and the Sub-Committee will meet at an early date."

The National Wages Board for the railways concluded its sittings last Friday, when the claims made by the companies for reductions and variations in some of the railway working arrangements were further gone into by cross-examination. In the course of this last sitting, Mr. W. Clower regretted having heard the remark that the companies were guilty of a breach of faith. Trade unions did not believe they were guilty in that way when they asked for improvements in the conditions of service under the national agreement, yet as soon as the companies came forward with the suggestion that the time had come when certain points should be reviewed, they were accused of a breach of faith. The companies were trying to seek an adjustment which they thought was properly due and hoped the Board would consider the problem from that point of view. Mr. Thomas had referred to the spirit of sportsmanship displayed by the men and by the companies. He (Mr. Clower) hoped that spirit would be continued when the decision of the Board became known. The interests of the men and of the companies were identical; the prosperity of the one meant the prosperity of the other. At the preceding sitting, Mr. J. Bromley, secretary of the Locomotive Engineers' and Firemen's Union, gave figures illustrating the work required of stokers on the foot-plate of express locomotives. The Board is considering the problem and will issue its decision later. As was to be expected, the shareholders' position came up for consideration during the meetings, and questions were asked as to what sacrifices they had made. On this point the Scottish Railway Stockholders Protection Association stated that in 1912 the average dividend was 3·58 per cent. on English and Welsh railways, and 3·71 per cent. on Scottish railways. At the commencement of the war the railways were guaranteed by Government their net revenue of 1913, and during the war and after it the shareholders received only their pre-war dividend, in some years even less. The railway dividends have remained very meagre; the increase in wages since 1913 presents a remarkable contrast to them.

As announced in our last issue, representatives of the Shipbuilding Employers' Federation and of the United Society of Boilermakers and Iron and Steel Shipbuilders met in Edinburgh on Thursday, the 15th inst., when no final decision was arrived at. The conference was adjourned to the following day, when the dispute was settled, subject to the agreement arrived at being endorsed by a ballot of the boilermakers. The agreement in question reads as follows:

National Overtime and Nightshift Agreement.

"It is agreed that federated shipyards will, so far as work is available, be open to members of the Boilermakers' Society on the following basis, namely: The Federation will consider with the Society in Committee how far on the five points named by the society the operation of the terms of the National overtime and nightshift agreement reveals anomalies which need correction; or special circumstances peculiar to the members of the society, or any class of them, which need adjustment; failing mutual agreement in committee, the points of difference to be referred to the Industrial Court for determination, the terms of reference to be mutually agreed; provided that in the meantime the society agree that their members will operate the provisions of the agreement until, and accept it with, such corrections or adjustments as have been decided upon either by mutual agreement or by arbitration. Such corrections or adjustments, when decided upon, shall apply retrospectively from the date of the resumption of work. The delegate conference of the society agree to recommend to the society acceptance of the foregoing proposal of settlement." The men are recommended by their leaders to vote for the agreement. Work will be resumed as soon as possible after the result of the ballot is known. At the close of last Friday's conference the delegates sang "Auld Lang Syne." If, centuries ago, Nero had taken up his fiddle before setting fire to Rome, it would have been much better for Rome and for himself also. The delegates might have made it possible to sing the same fraternal song seven months ago!

The Ministry of Labour state that there was little change, on the whole, in the state of employment during October. Among workpeople insured under the Unemployment Insurance Acts, in Great Britain and Northern Ireland, the percentage unemployed was 11·7 on October 22, compared with 11·7 on September 24, and with 11·8 on August 27; at the end of October, 1922, the corresponding percentage was 12·3. Among members of trade unions from which returns were received the percentage unemployed was 10·9 at the end of October, compared with 11·3 at the end of September. The total number of workpeople registered at the Employment Exchanges as unemployed on October 29, in Great Britain and Northern Ireland, was approximately 1,296,000, of whom 970,000 were men and 246,000 were women, the remainder being boys and girls. On October 1 the total was 1,285,000, of whom 955,000 were men and 244,000 were women. Employment was good in the coal-mining industry and in the tinplate and steel sheet trades; fairly good in the coachbuilding and carpet trades; and fair in the building, brickmaking, jute and leather industries, and in some sections of the metal trades. In most of the other large industries it was slack or bad. As compared with the previous month, there was an improvement in the coal-mining industry, in tinplate and steel sheet manufactures, and in the pottery trade, but a slight decline in iron and steel manufacture.

The slight upward movement in rates of wages, which has been in progress since July, continued in October, though the numbers of workpeople affected and the amount of net increase were still relatively small. In the industries for which statistics are compiled by the Labour Department, the changes reported as taking effect during the month resulted in an aggregate increase of nearly 14,000*l.* in the weekly full-time wages of about 190,000 workpeople, and in a reduction of 8,500*l.* in the weekly wages of 66,000 workpeople. There were increases in the wages of iron puddlers and millmen in the North of England and the West of Scotland, blast furnacemen and iron and steel workers in South Wales, steel sheet millmen and galvanisers. Among trades covered by the Trade Boards Acts, the minimum rates were raised for workpeople employed in the hand-hammered chain trade, and in the perambulator and invalid carriage trade. The principal reductions in rates of wages affected iron miners in Cleveland and Cumberland, blastfurnace workers in Cleveland, and certain classes of skilled and semi-skilled men employed in the Thames ship-repairing industry. Up to the end of October the changes in rates of wages reported to the Department during 1923 have resulted in a net reduction of nearly 500,000*l.* in the weekly full-time wages of nearly 3,150,000 workpeople and a net increase of over 300,000*l.* in those of over 1,130,000 workpeople. In the corresponding period of 1922 there was a reduction of nearly 4,200,000*l.* in the weekly full-time wages of over 7,500,000 workpeople, and a net increase of nearly 11,500*l.* in those of nearly 75,000 workpeople.

The average level of retail prices on November 1 of the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 75 per cent. above that of July, 1914, as compared with 75 per cent. a month ago and with 80 per cent. on November 1, 1922. For food alone the corresponding percentage at November 1 was 73, compared with 72 a month earlier, and with 76 at November 1, 1922.

The number of trade disputes involving stoppages of work, reported to the Labour Department as beginning in October, was 41. In addition, 18 disputes which began before October were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in October was approximately 56,000, as compared with 54,000 in the previous month and 14,000 in October, 1922. The estimated aggregate duration of all disputes during October was about 1,167,000 working days, as compared with 1,029,000 days in September, 1923, and 186,000 days in October, 1922. The principal dispute in progress was that involving members of the United Society of Boilermakers and Iron and Steel Shipbuilders in federated shipyards, which began on April 30 and was still in progress at the end of October.

We read in *The Iron Age*, New York, that real wage earnings, or purchasing power of dollar earnings, as compared with cost of living, were 39 per cent. higher in August than before the war, according to figures compiled by the National Industrial Conference Board. Average hourly earnings in August were 54·8 cents. Average weekly earnings were 26·59 dols. compared with 26·66 dols. in July. While the real hourly earnings were 39 per cent. higher than in July, 1914, the real weekly earnings were only 31 per cent. higher, due to the shortening of the number of hours per week. But this means that the average wage earner covered under the survey is 31 per cent. better off in purchasing power than he was nine years ago, in addition to having the greater amount of leisure time indicated by the difference in length of work week.

The number of wage earners in 1,678 manufacturing establishments has decreased consistently since April. All of the monthly figures for 1923 to date are lower than the figure for the record month of June, 1920. At that date the number of wage earners was 697,965. In April of this year—the highest month of the year to date—the figure was 643,623. In August, the last month for which reports have been completed, the number was 613,101, a drop of 1¼ per cent. from 622,051 in July.

"THE CAUSES OF RAPID CORROSION OF CONDENSER TUBES."

TO THE EDITOR OF ENGINEERING.

SIR,—I am entirely in agreement with Mr. John Christie of the Electricity Works, North-road, Brighton, and consider that the troubles experienced in condenser tubes can be, in a great measure, overcome, if the electrolytic system of protection is correctly applied.

About ten years ago this firm built and completed the s.s. Alsatian for the Allan Line (now the Empress of France, of the C.P.S.), and shortly after starting service I was called to Liverpool to inspect the condition of the auxiliary condenser tubes, which had been in use for some months during the fitting out of the ship in Dalmuir Basin. I decided that they must be at once renewed, and it was agreed that Dr. Bengough should arbitrate and decide on whose shoulders the cost of the replacements should be borne. His report clearly indicated that the water in the Dalmuir Basin was the cause of the trouble. This firm, therefore, had to provide a new set of tubes without charge.

In the large power station here during 1916–17, it was found necessary to increase the electric output, which up to that time had been entirely generated by gas engines. A 1,500-kw. Ljungstrom turbine was installed with a condensing plant, and the circulating water had to be taken from the River Clyde, as in the case of the Alsatian. It was decided to fit the Cumberland electrolytic system to the condenser, and although—especially at low tides—the condensing water is absolutely full of foul gas, on no single occasion has any tube shown the slightest sign of pitting or corrosion and no deterioration has occurred. The tubes are of Admiralty composition, and to-day are as good as when installed six years ago. I took upon myself to inform the engineer-in-chief of the fleet of these results, and strongly recommended this system of protection for warships' condensers, with the result that it was subsequently adopted. Hundreds of condensers, of course, suffer from tube troubles, but the object of this letter is to point out that if the electrolytic system of protection is used, it is most helpful; proper metallic connection must, however, be made, and the tubes thoroughly cleaned out at every opportunity.

In the s.s. Conte Rosso, the main condenser tubes corroded rapidly. On making an inspection of the tubes at Genoa, they were found full of mud from the water being pumped through them when the ship was lying near the bottom in the harbours of Italy and South America. A new set of tubes had to be provided within a few months.

In the s.s. Conte Verde, as a result of the previous ship's experience, the tubes were washed and brushed through each voyage, and up to date, after seven months' service, not a single failure has been recorded. The tubes in the two ships are of the same composition and made by the same maker. The ships have been on similar service and are identical in all respects.

I have seen many cases of perforated tubes, and have in most cases found the tubes choked with ash, sea-weed or foreign matter at the perforated part. Thorough cleaning of tubes internally after each voyage is strongly recommended, and if electrolytic protection be correctly and intelligently applied, great benefit will certainly result. It is not seen how increase of speed of the water through the tube can cause pitting to occur: in fact, it should retard rather than cause such action.

Yours faithfully,

WM. ONYON.

Naval Construction Works, Dalmuir, Dumbartonshire, November 20, 1923.

SOLDERING MACHINE FOR TIN CANS.

CONSTRUCTED BY MESSRS. WILLIAM A. GREEN, LIMITED, ENGINEERS, LONDON.

SOLDERING MACHINE FOR TIN CANS.

CONSIDERING the enormous number of tin cans made and used in this country, it is somewhat surprising that the seams of those which have to be made fluid tight are generally soldered by hand, either by dipping the joint into a bath of molten solder or by means of an ordinary copper bit. Both these methods are slow and wasteful of solder, but, of the two, the former is preferable since it produces a much stronger joint. This is due to the fact that, if the operator carries out the work properly, the solder penetrates completely into the seam in which it is held by surface tension until it solidifies; whereas, if the solder is applied by means of a copper bit, it merely serves to close the opening at the joint. A very solid sweated joint can be obtained by dipping, but it is, of course, essential for the parts of the tin plate forming the seam to be in close contact; there is, however, no difficulty in securing this condition with modern seaming machinery. The drawbacks to hand dipping, however, are that it is a comparatively slow process, that it is difficult to secure uniformity in the work, and that much solder is wasted owing to the fact that it extends beyond the limits of the seam and the surplus is not properly drained off.

Several attempts have been made to carry out the soldering process by means of machinery, and a number of appliances for the purpose are already on the market. As a rule, however, the machines available are suitable only for one class and size of tins, so that it only pays to instal them in cases where a large and regular demand for one type of tin can is assured. In this respect the machine illustrated in Figs. 1 and 2, annexed, known as the Luxton-Green soldering machine, has the important advantage that it can be adjusted in a few minutes to deal with any ordinary size of square, rectangular or cylindrical tin. It can, therefore be employed by manufacturers of products supplied in tins, who invariably use several different sizes, as well as by firms who specialise in the production of the tin cans themselves. The output of the machine, we are informed, is approximately equal to that of 25 hand operators, and other advantages claimed by the makers, Messrs. William A. Green, Limited, 200, Westminster Bridge-road, London, S.E. 1, are a considerable saving in solder, stronger joints and superior quality of work.

The machine, as illustrated in Fig. 1, is arranged for soldering the end joints of square or rectangular tins. As will be seen, it comprises three cast-iron standards with their upper ends inclined at an angle of 45 deg. to the horizontal. The standards are connected to form an inclined frame in front of which are two shallow cast-iron troughs, that on the left of the machine containing the liquid flux and that on the right containing the solder; the latter is kept molten by a series of Bunsen gas jets, the pipes for which can be seen in the illustrations. The tins to be soldered are placed on the inclined frame at the left-hand side, the upper ends of the tins being supported by an angle bar, the position of which can be adjusted for tins of different lengths. The bottoms of the tins rest against a shaft which is driven by a circular belt at the left-hand side of the machine and runs in a clockwise direction when viewed from the right-hand end. The position of this shaft is adjustable in directions parallel with, and at right angles to, the inclined frame, and its objects are to locate the tins so that their lower edges just dip into the flux and solder contained in the troughs, and to prevent them from riding up as they travel along; the latter object is secured by the friction between the rotating shaft and the bottoms of the tins.

The longitudinal travel of the tins is effected by a series of cradles formed by prongs fitted at right angles into blocks mounted on the inclined shafts shown in Fig. 1. These shafts are alternately rotated through an angle of 90 deg. by means of pinions engaging with racks placed at the back of the inclined frame as shown in the illustration. The racks are given a longitudinal reciprocating motion to rotate the cradles by means of the two cams seen on the right of Fig. 1, and the arrangements are such that as the tins are fed on to the machine on the left-hand side they are picked up by the prongs of the first cradle, turned through 90 deg. and moved forward a distance equal to the width of one side. After remaining stationary in the new position for a short interval, they are moved in a similar manner by the next cradle. In this way they are passed along the machine from left to right, all four of the bottom edges being dipped, one after the other, first into the flux and afterwards into the molten solder. At the right-hand end of the machine, a bar is fitted near the front of the inclined frame, and the tins being delivered on to this bar by the last of the cradles are raised clear of the molten solder. The soldered tins may be removed by hand and passed through the machine a second time for soldering the joints at the other end, but it is obviously possible, if desired, to arrange for the tins to be supplied to, and taken from, the machine automatically by means of conveyors.

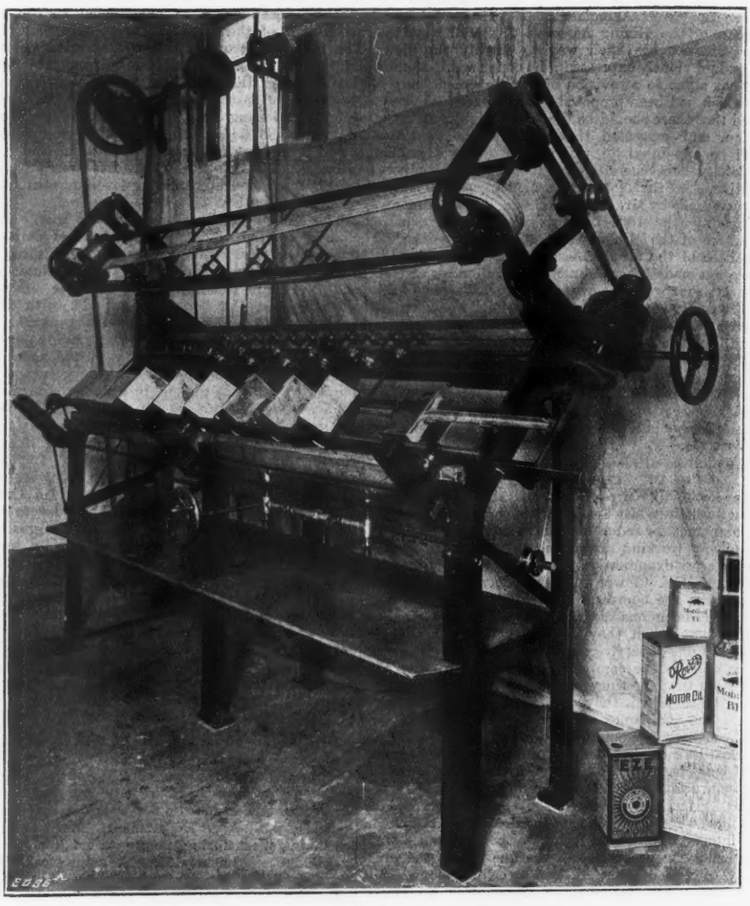


FIG. 1.

By means of a four-speed stepped-cone pulley the speed of the machine is adjusted so that each edge of a tin remains stationary in the solder just long enough to attain locally a temperature at least equal to the melting-point of the solder used, this being an essential condition in all kinds of soldering. With the work heated in this way, the surplus solder readily drains off as the tin is rotated, so that only what is actually retained in the seam is used. The heat, however, does not travel far along the body of the tin, since lettering printed by transfers on to the sides can extend to within $\frac{3}{8}$ in. of the seam without being scorched or injured in any way. The level of the molten solder in the trough is maintained sufficiently constant for all practical purposes by adding sticks of solid solder as required. We should also mention that the flux trough is fitted with a brush, the bristles of which point vertically upwards and thus serve to distribute the flux uniformly and also to render a careful adjustment of the level of the flux in the trough unnecessary. As previously mentioned, however, the extent to which the edges of the tins dip into the flux and into the solder can be varied while the machine is in motion by adjusting the position of the horizontal shaft in front of the machine. The adjustment of all three shaft bearings in a direction at right angles to the inclined frame is effected simultaneously by means of screw gear operated by a crank handle on the right-hand side of the machine, while the adjustment in a direction parallel with the frame is made by means of screwed collars provided on each bearing. The hand-wheel shown on the extreme right of the illustration is provided to enable the camshaft to be turned slowly while the cradles are being adjusted to handle tins of different sizes. The distance between the cradle shafts has, of course, to be adjusted in accordance with the widths of the sides of the tins, but as the bearings for these shafts are merely clamped to angle bars by single set screws at each end, they can be removed and replaced quickly and easily. The lengths of the prongs forming the arms of the cradles have also to be altered for the same purpose, the most suitable length for them being about two-thirds the width of the sides of the tins. The prongs, however, are plain lengths of $\frac{1}{4}$-in. mild steel rod fixed in brass blocks on the cradle shafts by means of set screws, so that they can be changed without much trouble. Complete sets of prongs covering all sizes included in the range of the machine are supplied with it, and the whole operation of setting up the machine to work on a different size of tin can be carried out by an experienced operator is about 20 minutes.

For soldering the ends of cylindrical tins, the rocking cradles are not required, the tins being rolled along the machine continuously from one end to the other by means of a cotton belt. Fig. 2 shows the machine arranged for this class of work. The belt runs on two pulleys mounted on shafts carried by a pair of articulated frames which constitute a parallel-motion mechanism. In Fig. 1 the belt is shown raised out of the way, but by means of a hand wheel conveniently placed in front of the machine, the articulated frames can be lowered into the position shown in Fig. 2, the face of the belt being kept parallel with the inclined frame which forms the table of the machine, throughout the whole of the movement. A number of weighted rollers, clearly shown in Fig. 2, keep the belt in contact with the cylindrical surface of the tins, which are thus drawn along by the motion of the belt. The end seams are soldered in exactly the same way as has been described above for dealing with square or rectangular tins, the only difference being that with cylindrical tins the movement is continuous instead of intermittent.

On the machine illustrated, the hand wheel used for raising or lowering the belt rotates a shaft at the back of the machine through worm gearing, and light wire cables attached to the articulated framework, as shown in Fig. 2, are wound on to, or unwound from, flanged rollers mounted on this shaft. In later machines it is

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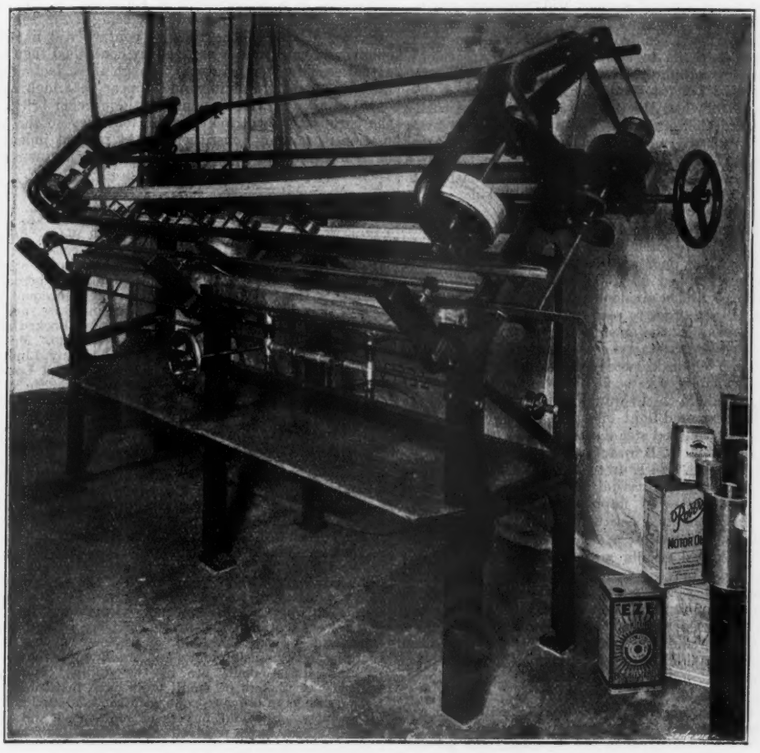


FIG. 2.

intended to replace the cables by toothed racks pivoted to the framework at one end and gearing with pinions mounted on the shaft in place of the flanged rollers. The reason for employing a parallel-motion mechanism for the framework supporting the belt is, of course, to secure a uniform contact between the face of the belt and the cylindrical surface of the tins irrespective of the diameter of the latter. Another point which may be mentioned in connection with the belt is that the latter can be moved laterally so that it makes contact with the tins about midway between the ends, this being desirable, although not often necessary, in order to avoid any tendency for the tins to slew round. The adjustment of the belt position is effected by moving the pulleys along their driving shafts and locating them by means of loose collars.

The machine can deal with cylindrical tin cans or drums ranging from 2½ in. to 14 in. in diameter and up to 21 in. in length, the output naturally varying according to the size, the gauge of the tin plate used and the kind of seam. As an example of the production, however, we may mention that 6 in. diameter tins can have one end soldered at the rate of about 2,000 per hour. Square or rectangular tins with sides ranging from 3 in. to 10 in. wide, and up to 16 in. in length, can be dealt with at the rate of from 900 to 350 ends per hour. Only one operator is required for the machine and less than 1 h.p. suffices to drive it. The floor space occupied is 10 ft. by 2 ft. 6 in. If square or rectangular tins only have to be dealt with, the machine can be supplied without the attachment for handling cylindrical tins.

We should perhaps point out, in conclusion, that the machine described above is only suitable, in general, for soldering the ends of tins. It is possible, however, to adapt it for soldering the longitudinal seams of square or rectangular tins when such seams are located on a corner and the radius of the latter is not too great. For this purpose a separate belt driven by a pulley on the cam-shaft is employed, and the belt is provided at intervals with projections which draw the tins along in the direction of their length so that the corner seams pass through the flux and solder. Without this arrangement, which cannot be used with cylindrical tins, the longitudinal seams must be soldered by hand.

PLATINUM SUBSTITUTES.

ON Friday, November 16, Mr. E. A. Smith, A.R.S.M., delivered a lecture to the Sheffield Section of the Institute of Metals, dealing with "Substitutes for Platinum." He said that the physical and chemical properties of platinum gave it a unique position amongst the useful metals, and its importance in the realms of science and industry could hardly be over-estimated. It was not surprising, therefore, that the demand for platinum had increased very considerably during the past few decades; unfortunately, however, the production of the metal was limited, and the world's total output had for some years been quite inadequate to meet the ever-increasing demand. In consequence, the price had risen very rapidly until it was now approximately six times that of gold weight for weight. The phenomenal activities in all branches of scientific research and in manufacturing enterprises during the past twenty years had resulted in a continually increasing consumption of platinum, whilst statistics showed that owing to the falling-off of supplies from Russia, the world's production of the metal had been on the decline. This shortage of platinum had recently become so acute that active research had been carried out, especially during the past five years, in order to find substitutes wherever possible. As a result, a number of alloys had been suggested, and some few of them had proved successful for certain specific purposes and had begun to take a more or less prominent place in industry. Research, the lecturer proceeded, had failed to produce a substitute which in all its properties could take the place of platinum for general purposes. The possibilities of finding such a substitute were somewhat remote.

In considering platinum substitutes, the lecturer stated that it should be borne in mind that in the case of platinum itself it was seldom that all its combined valuable chemical and physical properties were required for its application to specific purposes; usually only two or three of its properties were absolutely necessary, whilst others were only of secondary importance in the particular use to which the metal was being put. Owing to these facts it had become possible to find suitable substitutes for platinum in a few well-defined cases. The electrical and chemical industries absorbed comparatively large amounts of platinum, while the metal was also used in dentistry and jewellery.

A number of more or less successful substitutes had been introduced in recent years in the electrical industry, notably in connection with electrical resistances, contact points on ignition and lighting systems, and the spark plug points of internal-combustion engines. A common use for platinum at one time was in the lead-in wires conveying current to the filament of electric incandescent lamps and similar apparatus, because the metal possessed a coefficient of expansion similar to that of glass and in consequence could be sealed through glass. The iron-nickel alloy known as "Platinite," containing 46 per cent. of nickel and about 0·15 per cent. of carbon, had practically the same coefficient of expansion as glass, and could be drawn into fine wire which could then be coated with copper and again with platinum.

A similar copper-clad nickel-steel was known as "Dumet." Such wires could be sealed through glass without undue trouble and were extensively used in the electrical industry.

The so-called platinum employed almost universally for the contact points in electrical work was not the pure metal, but an alloy of platinum and iridium in which the proportion of the latter ranged from 15 per cent. to 50 per cent. for different classes of work.

Substitutes of lower price had been introduced, metallic tungsten, for example, was extensively used in the United States, and to a small extent in this country, but this metal had, in general, only about one-third of the life of a 75 : 25 platinum-iridium alloy. Watson, in a recent paper on magneto manufacture, had pointed out that tungsten suffered chiefly from oxidation, for, whilst its melting-point was much higher than that of platinum, it oxidised readily in air if raised to a red heat. Although no visible glow occurred at the contact, very minute local heating did apparently take place, and the points gradually oxidised.

The film of oxide thus produced not only tended to cause irregular running at normal speeds, but the extra resistance in the primary circuit made the slow speed performance of the machine inferior to that obtained when platinum points were fitted, the effect becoming more pronounced after the machine had been in service for a short time. Molybdenum had also been tried with much the same results. The ease with which these two metals oxidised and the difficulty experienced in soldering them had recently been overcome, however, by coating them with gold alloyed with 1·5 per cent. of platinum. This coated material had met with a ready demand in America for spark plugs and was finding favour in this country. Various alloys of nickel with tungsten, silver, copper and other metals had been tried and much progress made, but so far no entirely satisfactory substitute for platinum for many high-duty electrical contacts appeared to have been found. Nickel containing 3 per cent. to 5 per cent. of manganese was one of the latest alloys of this class. It was now largely used for spark plugs and was said to be giving satisfaction. Stainless steels and such materials as "Stellite" (containing 75 per cent. cobalt, the remainder being chromium with a little tungsten) had been suggested as suitable for contact points, but they did not appear to maintain their non-oxidising property under the intense local heating which took place, and so far, had proved to be practically of no value for this purpose. According to Fahrenwald the gold-palladium alloy "Rhotanium" was a satisfactory material for terminals in many forms of automatic electric devices.

Its behaviour when tested on certain magnetos was stated to be satisfactory, but other experiments performed on a high-duty aeroplane engine magneto had given negative results. Silver-palladium alloys containing 60 per cent. of silver and 40 per cent. of palladium had also been used in spark plugs and proved satisfactory in resisting spark erosion.

Turning to metals for electrical resistances, the lecturer stated that alloys containing a considerable amount of platinum which had long been used, were now very largely replaced by base-metal alloys. It was in this field that platinum substitutes had found their most extensive application. The most prominent material of this class was the series of nickel-chrome alloys which had been developed in recent years and had taken so prominent a place in industry. A high-grade nickel-chromium alloy had a specific resistance of about 120 michroms per cubic centimetre. Other alloys possessing a high specific resistance, and extensively used in electrical engineering, mainly as resistance materials, were fully described by the lecturer. These included the nickel-copper-iron alloys, certain cupro-nickels and nickel-silvers. "Monel" metal, "Constantan" and "Ferry" were briefly dealt with in passing.

Another important branch of electrical work in which substitutes had found wide application, was in pyrometric measurements. Since the introduction of the

platinum and platinum-iridium or rhodium thermo-couples in 1887, enormous strides had been made in industrial pyrometry, and it had followed naturally that investigations had been made with a view to discovering substitutes for the very high-priced rare metals. Platinum thermo-couples were undoubtedly still the best for research work and technical measurements where reliability was the first consideration. A number of base-metal couples had, however, been introduced recently and had given very satisfactory results for a number of industrial purposes where the prohibitive price of platinum would have made the introduction of thermo-couples impossible. Thicker wires could be employed, thus not only minimising errors experienced by the use of thin wires but also adding to the robustness of the instrument. Another important feature, from an industrial standpoint, was that base-metal couples did not require the same thorough protection as was the case with platinum alloys. Again, the thermo-electric power of the various base-metal couples was much greater than that of the platinum, platinum-rhodium couple. For temperatures up to 1,000 deg. C., base-metal couples were now in constant use and had proved very satisfactory, the most recent and probably the most useful being, the lecturer said, the "Chromel-Alumel" couple developed by Hoskins and largely used in America. This could be used continuously for temperatures up to 1,100 deg. C., and, for short periods, was able to register up to 1,300 deg. C. "Chromel" was a nickel-chromium alloy, and "Alumel" contained 98 per cent. of nickel and 2 per cent. of aluminium.

Turning to the chemical industry, the lecturer stated that platinum had proved invaluable in that sphere on account of its ability to withstand the action of acids and alkalies, and also because exposure to high temperature left it unchanged. Its use in the chemical and physical laboratory had done much to advance knowledge in these two important branches of science.

On the manufacturing side, pans or stills of platinum, each weighing as much as 2,000 oz., had, up till quite recently, been in use for the concentration of sulphuric acid. Anti-corrosive and acid-resisting chemical ware was a modern development and was gradually increasing in importance. The iron-silicon alloy sold under the special trade names of "Tantiron," "Duriron," "Ironac," and "Narki," was one of the most important of the series. The best brands contained about 15 per cent. of silicon with minimum quantities of impurities, especially graphite and phosphorus. These alloys were hard and brittle, and the casting of them presented difficulties, but their resistance to corrosion by nitric and sulphuric acids was so remarkable that they had rapidly established themselves as standard material for the manufacture of plant for these substances. Basins for use in the "cascade" system of sulphuric acid concentration had been made of this material for some time and, recently, had reached the large dimensions of 3 ft. in diameter. Pipes, cocks, coolers, nitric acid condensers, and other apparatus erected by chemical engineers, were now commonly made of iron-silicon. Unfortunately it did not resist well the action of hydrochloric acid or of chlorides.

With regard to non-ferrous alloys, nickel-chromium alloys had proved to be excellent substitutes for platinum in many installations, expecially catalytic chemical plants. Those alloys containing from 15 per cent. to 50 per cent. of chromium resisted nitric acid perfectly, were very ductile, could be forged and possessed a high tensile strength. Moreover, they did not scale even after prolonged heating to a red heat, and also retained their hardness. A cheaper alloy, made by introducing the chromium in the form of ferro-chrome, contained from 15 per cent. to 25 per cent. of iron. It possessed most of the properties of the simple nickel-chromium alloys, but was not quite equal to the iron-free material.

Alloys of palladium and gold, under such trade names as "Rhotanium" and "Palau," had recently taken a prominent place in America, stated the lecturer, and were chiefly used in the manufacture of the smaller laboratory ware.

COMPOSITION OF LIGHT OILS FROM CARBURATED WATER GAS.

Following the report on gummy deposits in gas meters, which we noticed on page 439 of our issue of October 5, the United States Bureau of Mines has issued a further Investigation Report (serial No. 2537) on the "Relation of Operating Practice to Composition of Light Oil from Carburated Water Gas." The report is drawn up by Ralph H. Brown, E. F. Pohlmann and H. G. Berger. The previous work had shown that the formation of gummy deposits by any gas depends upon the quantity and composition of the light oil it carries. The light oil has its pyrogenetic origin in the gas oil used in the carburation, and its properties depend upon the way in which the carburation is conducted, that is to say, chiefly upon the amount and character of the gas oil used in carburating the blue water gas and upon the processes of carburation and of purification. The new report deals with the cracking, under identical conditions, of three typical American gas oils, the only variables being the gas oil used and the temperature.

Two of the oils tested were of Mid-Continent origin; the third came from California. A Mexican oil was also to have been studied, but it differed too much from the other oils to admit of identical treatment. Oil No. 1 was a light yellow gas oil of density 0·8419 and viscosity 1·2 (at 60 deg. F.); oil No. 2, a thin dark brown oil, had the density 0·8934 and viscosity 11; the third, Californian, oil was a black viscous crude of density 0·9365 and viscosity 53·4. The thermal tests yielded the following temperatures in the three cases in deg. F.: cold test 5, 35, 25 deg.; flash tests 216, 257, 269 deg.; fire test 230, 273, 304 deg. The oils, introduced at the rate of 2·5 cub. cm. per minute, were cracked in the tubular furnace in an atmosphere of blue gas; two cracking temperatures were used in each case, 1,350 deg. and 1,400 deg. F.; oil No. 1 was further cracked at 1,300 and 1,450 deg.; these temperatures are equivalent to about 705, 735, 760, 790 deg. C. In order to recover the light oil produced by the cracking, the gas, after passing through a cotton scrubber, a water condenser and coarse and fine calcium chloride, was sent through two copper coils in which it was cooled down to −20 deg. C. (−4 deg. F.), and then through a high column of wash oil. The recovered light oils were subsequently separated by fractionated steam distillation at temperatures A up to 100 deg. C., B up to 120 deg., C up to 140 deg., D up to 160 deg. and E up to 200 deg. C. By light oil is here understood a gas oil boiling below 200 deg. C. Apart from traces of naphthalene, those light oils would be the main constituents likely to condense in the distributing system.

The analytical results are of considerable interest, though they require further confirmation. As the cracking temperature was raised above 1,350 deg. F., the amount of light oil recovered per unit volume of gas oil decreased, from 6·7 per cent. down to 4·5 per cent., the percentages referring to the gas oil used. The Californian oil gave less light oil than the two Mid-Continent oils, and the temperature influence was less marked in the former case. There was further, as the temperature was raised, particularly again with the oils No. 1 and No. 2, a relative diminution of the higher-boiling fractions D and E, whilst the percentages of benzene and toluene increased. With higher cracking temperatures carburated water gas would, therefore, yield less material of low vapour pressure and high unsaturation likely to form drip oil and gummy deposits. The total amount of unsaturated compounds (as determined by the bromine test) expressed in per cent. of light oil varied between 18·5 and 11 in the case of oil No. 1, for the cracking temperatures stated; the ranges for the other oils were smaller. Referred to the original gas oil, the total unsaturation represented not much more than 1 per cent.

Large proportions of those unsaturated compounds (0·8 and more of the total) consisted of the fractions D and E. This is the important novel observation and confirms the previous experiments of R. L. Brown, who found that drip oil, the natural condensate collecting in the distributing systems of carburated water-gas plants, is to the extent of nearly one-half constituted of hydrocarbons of these ranges of boiling point. Fraction D, it was ascertained in the present research, is mainly styrene (phenylethylene), C_8H_8, a compound which is related to the cinnamon bodies; in the pure condition it forms a colourless liquid of aromatic smell, which readily polymerises into the solid metastyrene. Fraction E consisted largely of indene, C_9H_8, another unsaturated compound of noted instability. The indene molecule may be said to represent a combination of a benzene hexagon with a five-corner polygon, instead of the combination of two hexagons having one side in common which is accepted for the naphthalene molecule $C_{10}H_8$. Indene is likewise a colourless liquid which polymerises quickly, even under exclusion of oxygen. Both styrene and indene have long been known; indene was found in the Hamburg coal gas by Dennstedt and Ahrens in 1891 and subsequently recognised as one of the regular minor constituents of coal gas. But the suggestion that these two bodies are mainly responsible for the gummy deposits is novel; till recently the olefines, unsaturated hydrocarbons of the $C_n H_{2n}$ type, had been considered the chief culprits, although much attention has been devoted to the deterioration of gas meters lately.

As regards thermal stability, the aromatic hydrocarbons (benzene and its homologues) seem to break down in the ascending order naphthalene, benzene, toluene, xylene and higher homologues, that is to say, the higher homologues are the less stable at high temperatures. Indene, though a relatively high temperature product, would also be less stable at higher temperature, since its amount decreases when the cracking temperature is raised. Excessive amounts of indene in carburated water gas would then indicate that the cracking temperature was kept too low. That conclusion is in accord with the statistical data referred to in our article on gummy deposits, which showed that the gum troubles were stronger when cracking had been conducted at a temperature of 1,329 deg. F. than at 1,374 deg. F., these temperatures being averages. In practice, of course, the time of contact will likewise count, and that time is more easily controlled than the actual cracking temperatures, though these factors are interdependent. But it would appear that high rates of oil input and wide spacings of the checker bricks in the carburators will increase the tendency to the formation of gummy constituents. At present indene is of little use technically, except for making lacquers and varnishes.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Despite the uncertainty caused by the political position evidence is accumulating of a steady revival in the local engineering and allied trades. A feature is the improved demand on home account for heavy machinery. Many promising inquiries are in circulation, and actual contracts are being booked at a much quicker rate than three months ago. Messrs. Cravens Railway Carriage and Wagon Company, Limited, of Darnall, have secured an order from the London and North Eastern Railway of the approximate value of 100,000*l.*, for the supply of eight first-class carriages, 18 third-class carriages, 2 composite carriages and 4 third and brake carriages. The execution of this contract will supply six months' work. Agricultural engineering requirements have rarely been so few. Sheffield is doing very little business either with Lincoln or Gainsborough, but on the other hand there is an improved call for special steels and castings from the automobile industry, and a decidedly upward movement in wagon construction and small implements on colliery account. Sheffield expects to provide a heavy tonnage of steel castings and fittings in connection with the light cruiser contracts projected by the Government. The popularity of rustless steel castings for engineering use is steadily gaining ground. Orders are in hand in this connection for railway carriage fittings, water taps and other household accessories, sluice valve castings and expansion joints and small valves for marine engines. Twist drills are in the dumps, though a minority of makers of small tools have instituted continuous shifts in order to cope with the increased volume of business. Sheffield buyers of high-speed and other special steels have received offers from German and Czecho-Slovakian agents to stock their works with unlimited tonnages at prices on the average 18*l.* per ton below local cost. Remarkable credit facilities are offered. Users are informed that they need pay only as and when the material is used. In raw and semi-finished materials prices are steadily hardening. Forge and foundry pig-iron shows an advance of from 2*s.* 6*d.* to 3*s.* 6*d.*, as compared with a month ago. Revised official quotations are as follow:—Hard basic billets, 7*l.* 5*s.*; soft basic billets, 8*l.* 5*s.*; West Coast hematites, 5*l.* 12*s.* 6*d.*; East Coast hematites, 5*l.*; Lincolnshire No. 3 foundry, 4*l.* 14*s.*; Lincolnshire forge, 4*l.* 12*s.* 6*d.*; Derbyshire No. 3 foundry, 4*l.* 12*s.* 6*d.*; Derbyshire forge, 4*l.* 10*s.*; bars, 12*l.*; sheets, 15*l.*

South Yorkshire Coal Trade.—Fine slacks and inferior smalls comprise the only weak feature of the market. The former are offered slightly below official rates in order to clear accumulations at the collieries; otherwise prices are uniformly firm. House coal has received a distinct fillip from the wintry weather, there being a marked increase in Metropolitan purchases. Best steams are steady both on home and export account, despite wagon shortage and docking delays. Cobbles and nuts have improved under the influence of a stronger demand for export. Quotations:—Best branch handpicked, 31*s.* 6*d.* to 32*s.* 6*d.*; Barnsley best Silkstone, 27*s.* 6*d.* to 29*s.*; Derbyshire best brights, 27*s.* to 29*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 21*s.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Output of Cleveland pig-iron is being increased by the re-lighting of an idle blast furnace or two, but expanding needs promise to absorb the production, and values are well maintained. Business continues fairly active. Requirements of local foundries are growing, and other home trade is improving, whilst there is a little more doing on export account. Under such conditions prices are well upheld, and makers are less keen than are customers to negotiate for forward contracts. Amongst recent sales are quite good parcels for Scotland. No. 1 readily realises 107*s.* 6*d.*; No. 3 g.m.b. is steady at 100*s.*; No. 4 foundry is fully 99*s.*; and No. 4 forge is put at 97*s.* 6*d.*—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Good demand continues for East-Coast hematite iron notwithstanding recent very substantial sales, some of which are for delivery over the first half of next year. Local buying is large and increasing, purchasing for the Sheffield district, and for Wales keeps

on quite a good scale, and Continental inquiry shows improvement. Makers are now in a stronger position than for a long time, being well sold, and carrying low stocks. Under such conditions it is not surprising to find values tending upward. The minimum home and export quotation for Nos. 1, 2 and 3 is now 10*l.* 6*d.*, and most makers ask 10*l.* 10*s.*; whilst No. 1 is at a premium of 1*s.*

Foreign Ore.—There is rather more doing in foreign ore and prices are stiffening. Considerable sales of good Mediterranean ores have been made at 20*s.* to 21*s.*, and up to 21*s.* 6*d.* is now asked, whilst best rubio is quoted 23*s.* 6*d.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is moving up once more, average qualities having become 38*s.* 6*d.* delivered to local consumers.

Manufactured Iron and Steel.—Heavy inquiries are circulating for finished iron and steel, and producers have now quite good order books. All quotations are very strong. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium) 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles and joists, 9*l.* 10*s.*; heavy sections of steel rails, 9*l.* to 9*l.* 10*s.*; fish plates, 13*l.*; and galvanised corrugated sheets, 19*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A much improved tone falls to be recorded in the Scottish steel trade this week, and there are prospects that the boilermakers' ballot now being taken will result in the resumption of these workers by the beginning of next week. Should that take place it is anticipated that trade will open out and general business will improve, as buyers, who have been holding off for some time back, will again enter the market. The demand for ship plates is still poor, but once the shipyards get moving there is bound to be more doing, while quite a good business continues to be put through in sections. The railway companies have recently been giving out orders for quite a lot of material, and some firms have booked a fairly large tonnage. The black sheet trade shows a little change for the better. Producers have well-filled order books for the lighter gauges for export, and home consumers of the heavier sorts have been placing orders a little more freely. Galvanised sheets are also in better demand. An item of importance this week is the fixing up of an arrangement with the English makers whereby they will not undersell in this district. Rather unexpectedly at the end of last week the local makers made a reduction of 5*s.* per ton in the price of ship plates and sections. This was not generally anticipated as pig-iron prices have had a hardening tendency. Export trade overall is a shade better. The following are the market quotations for home delivery:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The slight improvement in the West of Scotland malleable iron trade, referred to last week, has been well maintained and several of the works are better off for tonnage. When work in the shipyards has been resumed there is the prospect of increased employment at the bar-iron works. For re-rolled steel bars there still exists quite a healthy demand. To-day's price for "Crown" bars is 12*l.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—The trade in Scottish pig-iron is steadily getting better and makers report an improvement in forward orders. Large stocks are general, but these would be considerably reduced if any buying movement should commence, and some makers hold that there is quite a probability of such a thing at no distant date. Inquiries are more numerous, and hematite iron is in better demand than it has been for some time. The prices all round are firmer and the following are to-day's quotations:—Hematite, 5*l.* 5*s.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 8*s.* 9*d.* per ton, and No. 3, 5*l.* 3*s.* 9*d.* per ton, both on trucks at makers' yards. It will be noted that foundry iron is 3*s.* 9*d.* per ton up over the week.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, November 17, amounted to 2,183 tons. Of that total 2,045 tons went foreign and 138 tons went coastwise. For the corresponding week of last year the figures were 1,321 tons overseas and 116 tons coastwise, making a total shipment of 1,437 tons.

DISC LOADING TYPE OF AUTOMATIC GRINDING MACHINE.—ADDENDUM.—On page 249 of our issue of August 24 last we gave a short description of a vertical spindle surface grinding machine of the Blanchard Machine Company, of Cambridge, Mass, U.S.A., whose agents in this country are Messrs. Burton, Griffith and Co., Limited, 64-70, Vauxhall Bridge-road, S.W. 1. We are now informed that the speed of the loading disc on which the pieces are just placed is quite low (6 ft. to 8 ft. per minute), and that consequently centrifugal force does not play any part in spreading the pieces out in line round the edges. The work after dumping in the centre is distributed round the edges of the revolving table by hand and is then carried forward to the magnetic chuck. The feeding disc runs at a higher speed than the chuck as was clear from our description, and consequently there is a tendency for the work to be fed forward and pushed on to the chuck by the table.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Market.—Shipping delayed by the gales has come to hand more freely during the past week, and this has materially strengthened the position of the coal market, though in isolated cases it is still possible for buyers, able to take immediate delivery, to secure slight concessions from colliery salesmen needing a quick clearance of loaded wagons. Most collieries are well sold up till the end of the year and, providing tonnage arrives to pick up the cargoes, are in a comfortable position. The weather, however, cannot be depended on, and it often happens that a colliery well sold on paper is sometimes in a worse position than another concern not so well sold, because of the failure of expected shipping to arrive and the consequent inability of exporters to accept deliveries. In order to avoid pit stoppages through wagons being detained at the docks, it is thus necessary to make sacrifices to those in a position to give immediate clearances with the result that buyers able to take advantage can often obtain bargains. The forward position, too, is good, for contracting has been on a fairly heavy scale for delivery over next year. In fact, most of the colliery companies have closed their books for the present, intimating that they already have sufficient orders in hand. For prompt loading best Admiralty large coals rule from 28*s.* to 28*s.* 6*d.*, with the leading Monmouthshires from 26*s.* to 27*s.*, and drys round 27*s.* Smalls of most classes have become somewhat scarce owing to a reduction in outputs caused by temporary pit stoppages, and the best bunker sorts are now steady round 18*s.*, with the cheaper grades at relative levels. Chartering on the freight market has been exceptionally active during the past week, when vessels with a carrying capacity of nearly 450,000 tons were taken to load Welsh coal. This suggests that in the early future there is likely to be congestion at the docks, with the result that the decision of the coal trimmers and tippers to cease working the third shift at the beginning of next month is viewed with alarm by traders, for it would mean that tonnage would again be delayed by lengthy despatch and that steamers—instead of being able to go under the tips within a short time of arrival—would be compelled to wait for berths in addition to taking longer to load.

Iron and Steel.—The Stabilisation Prices Committee of the Welsh steel and tin plate trades have decided to advance the minimum price of tin plates by 4½*d.* per box to 23*s.* 6*d.* per basic box. It was also decided to reduce the price of tin-plate bars by 3*s.* 9*d.* per ton, making the official minimum 8*l.* 18*s.* 9*d.* per ton less 7*s.* 6*d.* rebate to tin works in the stabilisation scheme. At present the tin-plate market is firm and business has been concluded at as high as 6*d.* over the old minimum and 1½*d.* above the new minimum for option contracts over the first quarter of next year. Current prices are from 23*s.* 6*d.* to 23*s.* 7½*d.* Exports last week amounted to 26,400 tons, compared with 25,000 tons in the previous week. Shipments of tin and terne plates amounted to 10,547 tons, compared with 15,969 tons; black plates and sheets to 9,540 tons, against 5,965 tons; galvanised sheets to 475 tons, against 1,380 tons; and other iron and steel goods to 5,835 tons, against 1,695 tons.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—The well-known aeronautical designer, Mr. A. H. G. Fokker, will deliver a lecture giving the results of his experience with welded tube construction, and in connection with the development of cantilever monoplane wings, before the Institution of Aeronautical Engineers, on Friday next, the 30th inst. The lecture will be delivered in the hall of the Royal Society of Arts, John-street, Adelphi, W.C. 2, at 7.30 p.m., and the secretary informs us that a limited number of tickets is available for those who care to make early application for them. The secretary is Mr. L. Howard-Flanders and the offices of the Institution are at 60, Chancery-lane, W.C. 2.

UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS.—1923.—The twenty-ninth annual edition of this directory has now been issued. It has been compiled, chiefly from official sources, under the direction of the editor of *The Railway Gazette*, and is published later than usual this year in order to include the numerous changes in *personnel* consequent on the grouping of the British Railways. It is divided into 11 sections dealing with the various institutions, scientific bodies and other societies, and giving the officials on the railways of Great Britain, Ireland, Europe, Asia, Africa, Australasia, North and Central America, Mexico and West Indies, South America, ending with a personal index of railway officials. It is published by The Directory Publishing Company, Limited, 33, Tothill-street, Westminster, S.W. 1, at the price of 20*s.* net.

INSTITUTION OF NAVAL ARCHITECTS.—The following scholarships will be offered for competition in 1924:—Naval Architecture: "Institution of Naval Architects (130*l.* per annum); "Beardmore" (150*l.* per annum) and the "Fairfield" (150*l.* per annum). Marine Engineering: "Weir" (150*l.* per annum) and "Yarrow" (100*l.* per annum). The scholarships are open to British apprentices or students and are tenable (subject to the regulations governing each scholarship) for three years at Glasgow University (with which is affiliated the Royal Technical College, Glasgow); Durham University (Armstrong College); Liverpool University; Royal Naval College, Greenwich; and the City and Guilds (Engineering) College; Imperial College of Science and Technology, London. Full particulars may be obtained from the Secretary, Institution of Naval Architects, 5, Adelphi-terrace, London, W.C.2.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 23, at 7.30 p.m., at 39, Victoria-street. Lecturette, "Technical Arbitrations," by Mr. W. A. Tookey, M.I.Mech.E. (Past-Chairman). Friday, November 30, at 7.30 p.m., Lecturette, "Notes on Design of Paraffin Motors," by Stratford C. Saunders (Member).

THE OPTICAL SOCIETY.—Tuesday, November 27, at 8 p.m., at the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, when the Thomas Young Oration will be delivered by Dr. M. von Rohr, Jena. Subject, "Contributions to the History of the Spectacle Trade from the Earliest Times to Thomas Young's Appearance."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 27, at 6 p.m. Papers to be submitted for further discussion: "The Effect of Groyning on Some Parts of the English Coast," by Mr. Richard Fuge Grantham, M.Inst.C.E.; "The Tides from an Engineer's Standpoint," by Mr. Edward William Hollingworth, M.A., M.Inst.C.E. Students' Meeting, Wednesday, November 28, at 6 p.m. Paper to be read: "Rotary Converters for Railway Use," by Mr. R. W. Mountain, B.Sc., Stud.Inst.C.E. Sir John F. C. Snell, M.Inst.C.E., will take the chair.

THE ROYAL SOCIETY OF ARTS.—Tuesday, November 27, at 4.30 p.m., at John-street, Adelphi, W.C. 2. Dominions and Colonies Section.—"The West Indies," by the Viscount Burnham, C.H., LL.D., D.Litt., M.A. The Lord Askwith, K.C.B., Chairman of the Council, will preside. Wednesday, November 28, at 8 p.m. Ordinary meeting.—"The Effect of Sun, Sea and Open Air in the Treatment of Disease," by Sir Henry John Gauvain, M.A., M.D., M.Ch., Medical Superintendent of the Lord Mayor Treloar Cripples' Hospital. Lord Dawson of Penn, G.C.V.O., K.C.M.G., will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 29, at 5.30 p.m., at Savoy-place, Victoria-Embankment, W.C. 2. Joint Meeting with the Physical Society of London. Subject to be discussed, "Loud Speakers for Wireless and other Purposes."

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, November 29, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. "The Development of High-Speed Aircraft," by Major R. H. Mayo, O.B.E., F.R.Ae.S.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, November 30, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Lecture: "The Result of Twelve Years' Welded Tube Construction and the Development of Cantilever Wings," by Mr. A. H. G. Fokker.

THE EFFECT OF AGE UPON CIMENT FONDU: ERRATUM.—We much regret that a typographical error crept into the table reproduced on page 631 *ante*, giving the results of ageing tests by M. le Gavrian on ciment fondu. The age given last in the table should be five years, not three, as will, we hope, be evident from the text and other data in the table. The tests were started in 1915 and 1916, and the effect of age up to three years has been known for some time. The certificate for the tests for periods up to five years has only lately been given.

THE ENGINEERS' CLUB.—The second annual general meeting of the Engineers' Club was held on November 14, the president, Sir Robert A. Hadfield, F.R.S., being in the chair. Sir Robert stated that the results for the year were surprisingly good under the existing circumstances. Mr. H. Foulds, chairman of the General Committee, drew attention to some items of the balance sheet. It was proposed by Sir Robert Hadfield and seconded by Mr. J. B. Whyte that Sir Joseph W. Isherwood, M.I.N.A., should be elected president of the Club. On this being passed, a vote of thanks to Sir R. A. Hadfield was moved and passed. In subsequent proceedings, Mr. E. L. Hill was re-appointed hon. secretary and Mr. H. Foulds hon. treasurer, while Messrs. Chantrey, Button and Co., were re-appointed auditors.

NITROGEN FIXATION BY MEANS OF SILICA GEL.—In the ordinary electric arc process for the fixation of nitrogen the concentration of the nitric oxide produced in the air is so low that the costs of recovering this oxide as nitric acid, nitrate or nitrite amount to a quarter of the whole operating costs. It has therefore been attempted to absorb the nitric oxide formed by means of silica gel, which, when subsequently heated, gives off the nitric oxide again in a concentrated condition suitable for direct liquefaction or for more profitable reabsorption. Some experiments to this effect, conducted by Edgar D. McCollum and Farrington Daniels, of the University of Wisconsin, are described in *Industrial and Engineering Chemistry*, of November. So far as the absorption by the gelatinous silica was concerned the experiments were successful. In other respects the simple arc arrangement adopted did not prove of any particular advantage. As the nitric oxide produced in the arc is quickly decomposed again by the heat of the arc, the products of the discharge are at once withdrawn from the arc. For this purpose McCollum and Daniels adopted upward circulation of the air in the discharge tube, through the gap between the horizontally-mounted electrodes (steel rods), and introduced an interrupter into the circuit so that the current was alternately on and off for equal short periods. No gain in yield was attained by this interruption.

PORTABLE CONCRETE MIXER AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO. (LEEDS), LIMITED, ENGINEERS, LEEDS.

(*For Description, see Page* 644.)

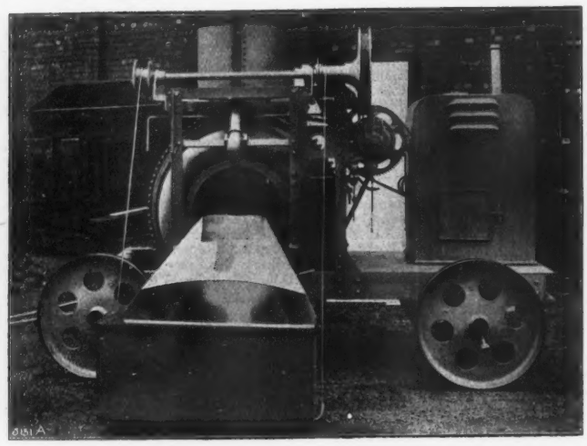


FIG. 15.

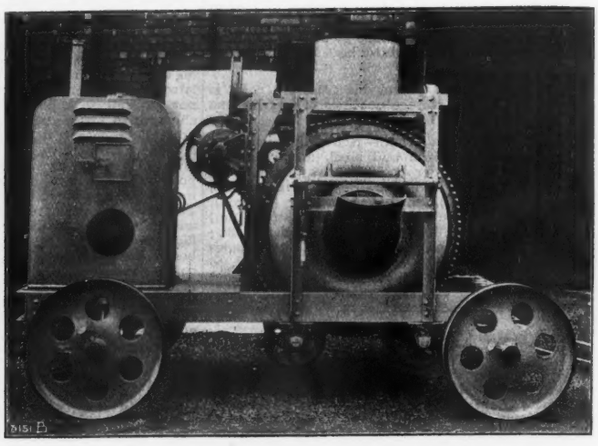


FIG. 16.

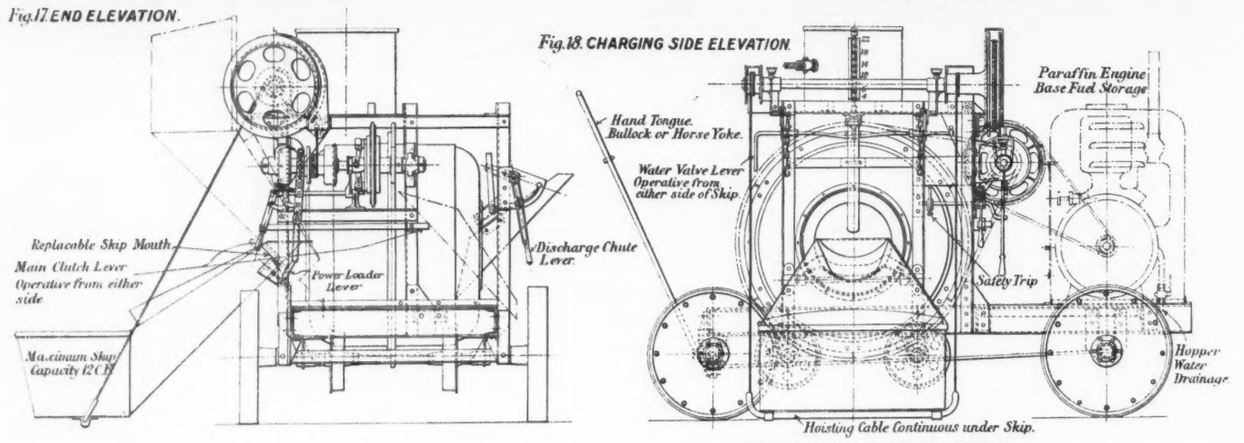
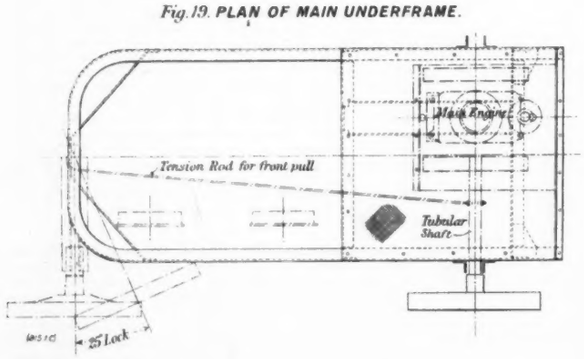
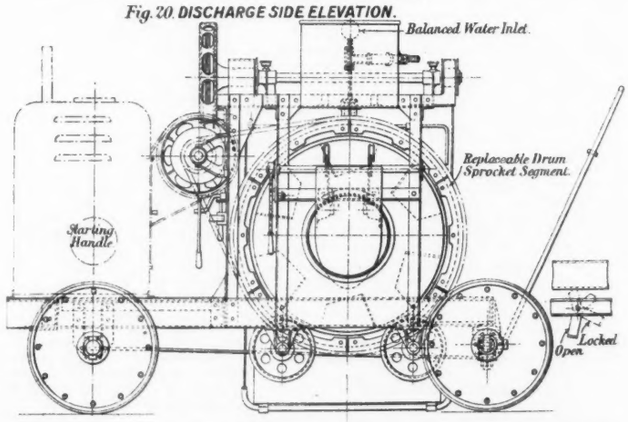


Fig. 17. END ELEVATION.
Replaceable Skip Mouth
Main Clutch Lever Operative from either side
Power Loader Lever
Discharge Chute Lever
Maximum Skip Capacity 12 C.F.
Fig. 18. CHARGING SIDE ELEVATION.
Paraffin Engine Base Fuel Storage
Hand Tongue. Bullock or Horse Yoke.
Water Valve Lever Operative from either side of Skip
Safety Trip
Hopper Water Drainage
Hoisting Cable Continuous under Skip.





AMERICAN PUDDLED IRON.—We read in *The Iron Age*, New York, that the new plant, at Warren, Ohio, of the American Puddled Iron Company, Youngtown, is virtually completed and ready for operation. It has an initial capacity for producing up to 250 tons of mechanically puddled iron and rolling up to 1,000 tons daily. Of four mechanical puddling units, only one has been put down so far, in order that its operation may be checked and changes made as experience dictates. When operations do start, they will be at a reduced rate, in order that the machinery may be given the proper tests. It is unlikely, therefore, that the plant will get under full headway for some time. It represents an initial expenditure of approximately 2,000,000 dols., and will manufacture at the start iron for pipe makers. We have always been under the impression that mechanical puddling, rotary puddling especially, did not yield fibrous iron as is the case with hand puddling, and left in the iron more slag than is the case with the latter. The precautions taken in putting down the plant referred to would seem to confirm our impression.

RETURNS OF VESSELS LOST, CONDEMNED, &C.—According to statistics just issued by Lloyd's Register of Shipping, the vessels lost throughout the world during the quarter ended June 30 last was 74 in number and had an aggregate gross tonnage of 100,820. British and Irish losses account for more than a third of the last-mentioned figure, amounting to 35,842 tons comprised in 10 ships; the British tonnage lost, however, only represents 0·19 per cent. of the total tonnage owned in this country. The United States of America lost 18 ships, with a total tonnage of 22,310, during the quarter, the loss, in this case, amounting to 0·15 per cent. of the whole American sea-going tonnage. Other losses during the quarter were the British Dominions, 7,106 tons (0·26 per cent.); Norway, 5,750 tons (0·23 per cent.); Holland, 3,627 tons (0·14 per cent.); Denmark, 3,297 tons (0·33 per cent.); Germany, 2,611 tons (0·10 per cent.); and Japan, 2,540 tons (0·07 per cent.). The tonnages given above are gross in all cases, and the figures include the losses of all vessels of 100 tons and upwards of which information was received up to October 17 last. They do not, however, include the cases of vessels broken up or condemned from causes not consequent upon stress of weather, &c. During the quarter under consideration such cases would account for 102 ships, making 281,225 gross tons in all, and, of this number, 19, making 45,861 gross tons, were owned in Great Britain or Ireland.

SCOTT-STILL ENGINE OF MOTOR SHIP "DOLIUS."

CONSTRUCTED BY MESSRS. SCOTTS' SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GREENOCK.

(*For Description, see Page* 639.)

Fig. 2. SECTION THRO' ATHWART CENTRE LINE LOOKING AFT

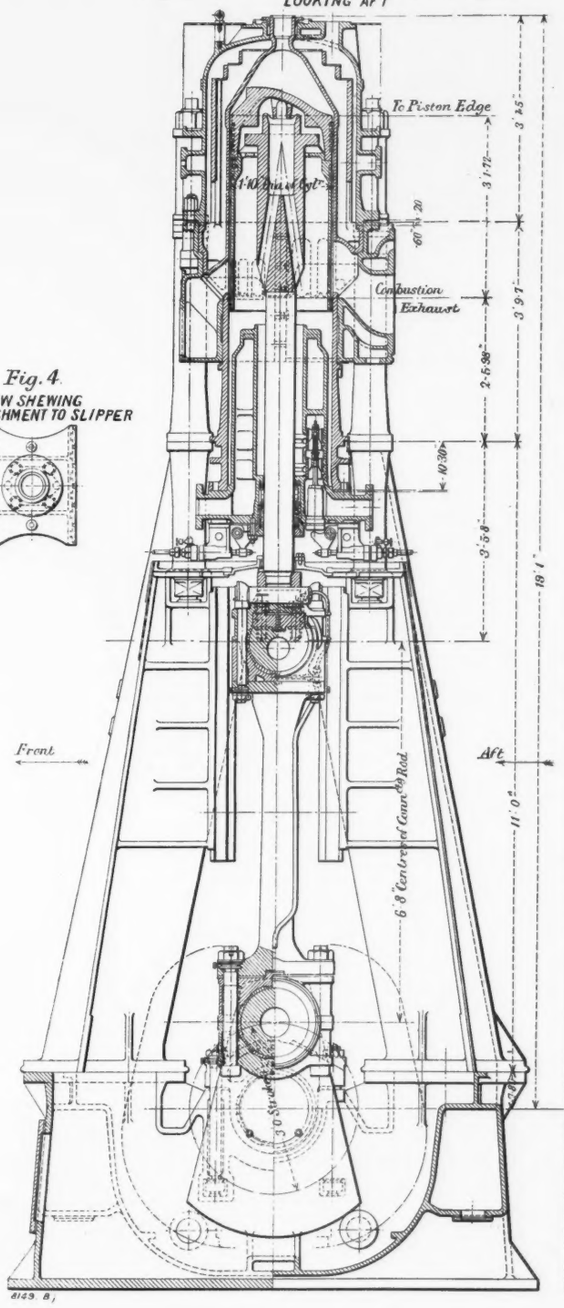


Fig. 3. SECTION THRO' FORE AND AFT CENTRE LINE

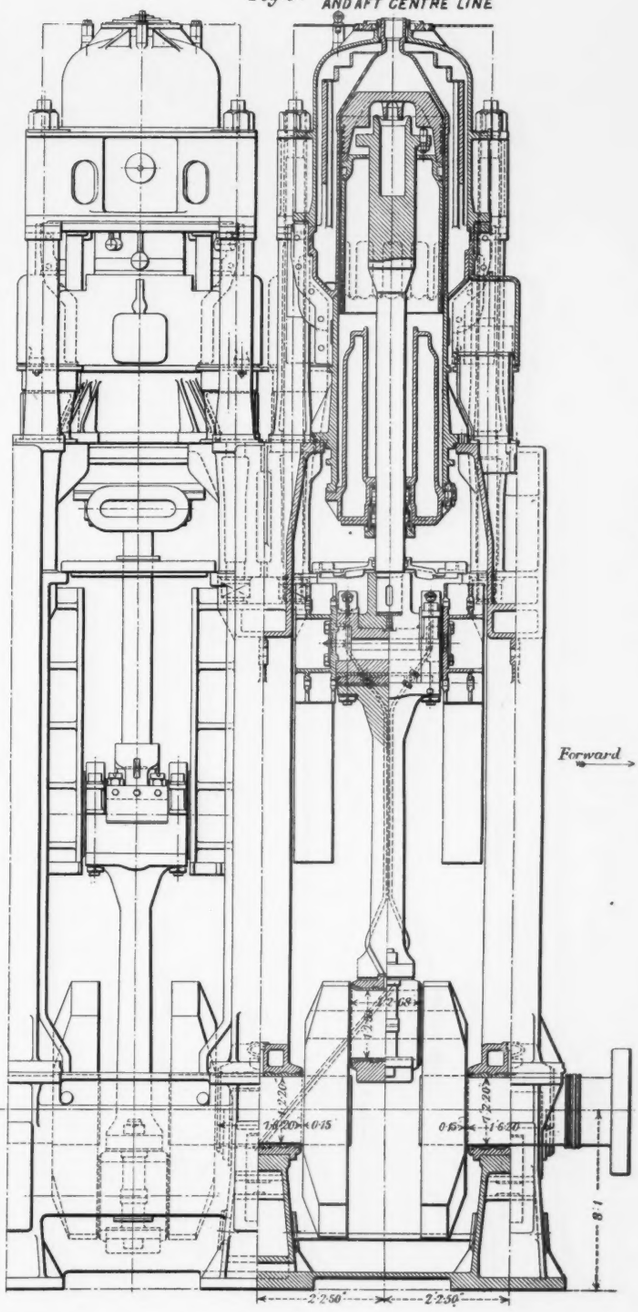
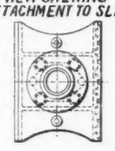


Fig. 4.
VIEW SHEWING ATTACHMENT TO SLIPPER



(*To face page* 640.)

GENERAL ARRANGEMENT OF MACHINE

CONSTRUCTED BY MESSRS. SCOTTS' SHIPBUILDING AND ENGI

(For Description see Page

Fig. 5.

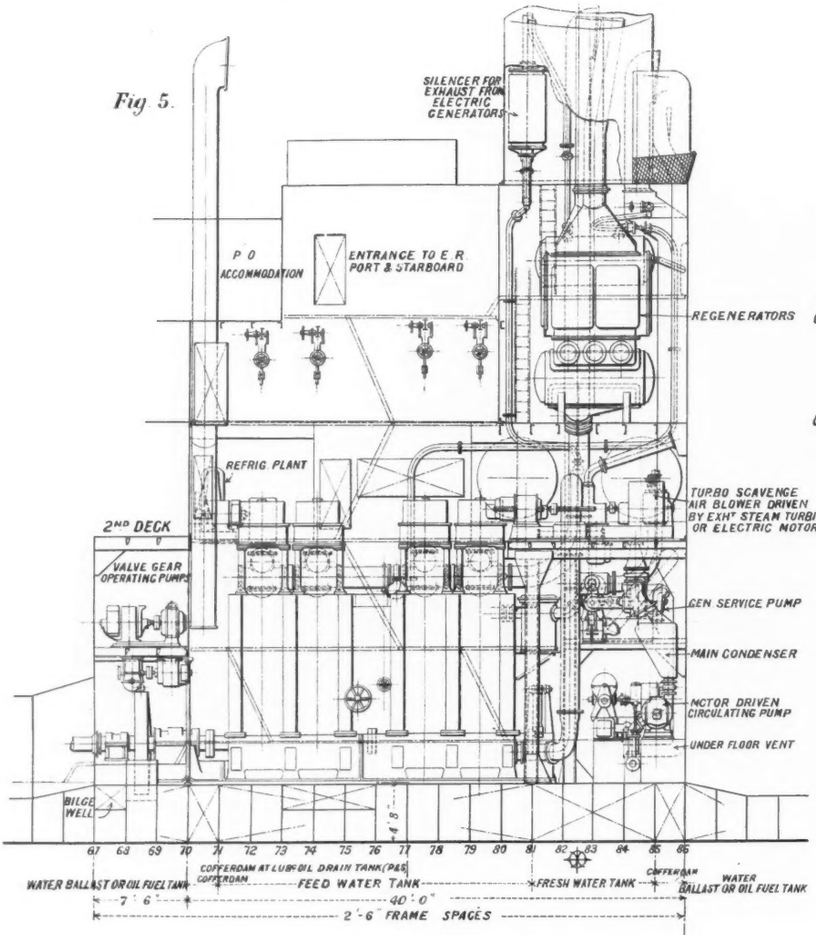

SILENCER FOR EXHAUST FROM ELECTRIC GENERATORS
P O ACCOMMODATION
ENTRANCE TO E.R. PORT & STARBOARD
REGENERATORS
REFRIG. PLANT
TURBO SCAVENGE AIR BLOWER DRIVEN BY EXHT STEAM TURBINE OR ELECTRIC MOTOR
2ND DECK
VALVE GEAR OPERATING PUMPS
GEN SERVICE PUMP
MAIN CONDENSER
MOTOR DRIVEN CIRCULATING PUMP
UNDER FLOOR VENT
BILGE WELL
61 63 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
COFFERDAM AT LUBR OIL DRAIN TANK (P&S)
COFFERDAM
FEED WATER TANK
FRESH WATER TANK
COFFERDAM
WATER BALLAST OR OIL FUEL TANK
WATER BALLAST OR OIL FUEL TANK
7'-6"
40'-0"
2'-6" FRAME SPACES

Fig. 8.

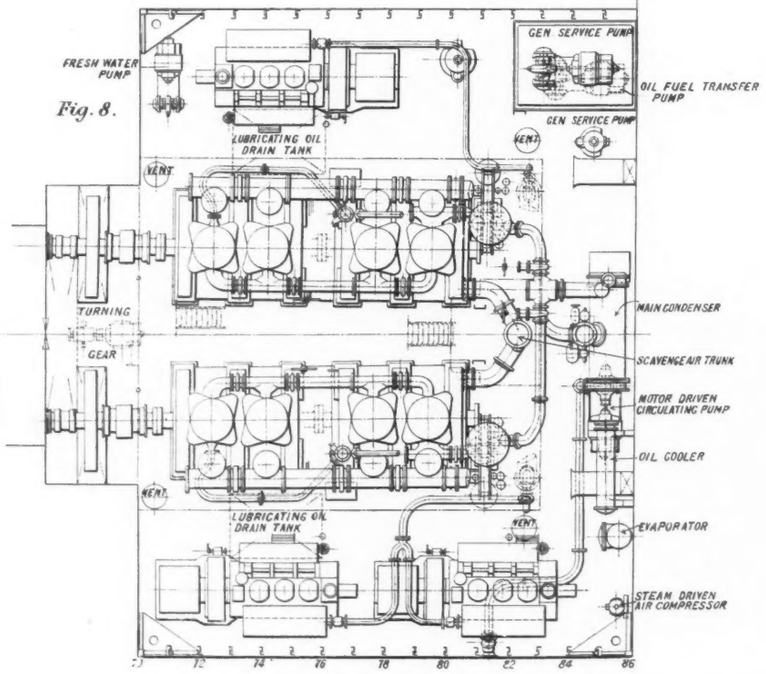


Fig. 6. SECTION AT FRAME 82

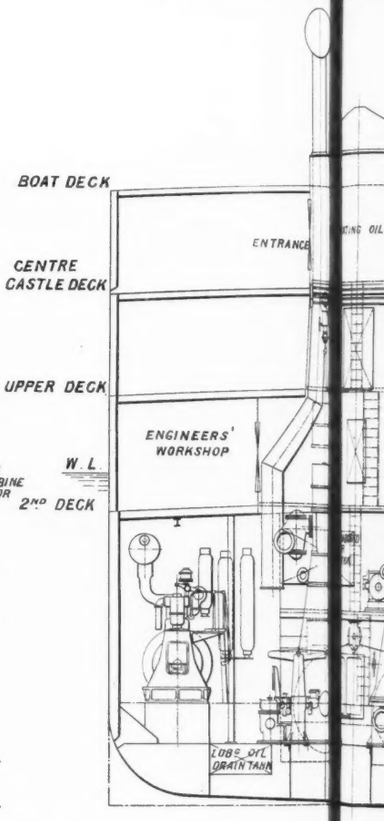
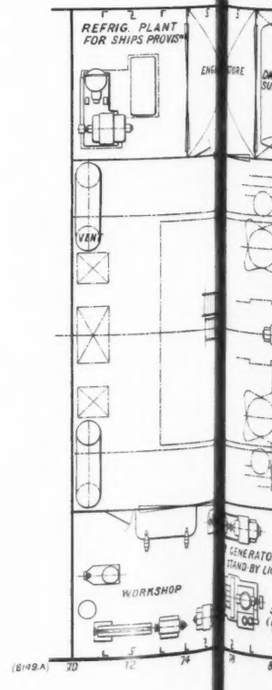


Fig. 9. PLAN OF DECK



MACHINERY OF MOTOR SHIP "DOLIUS."

PBUILDING AND ENGINEERING COMPANY, LIMITED, GREENOCK.

For Description see Page 639.)

TION AT FRAME 82 LOOKING AFT.

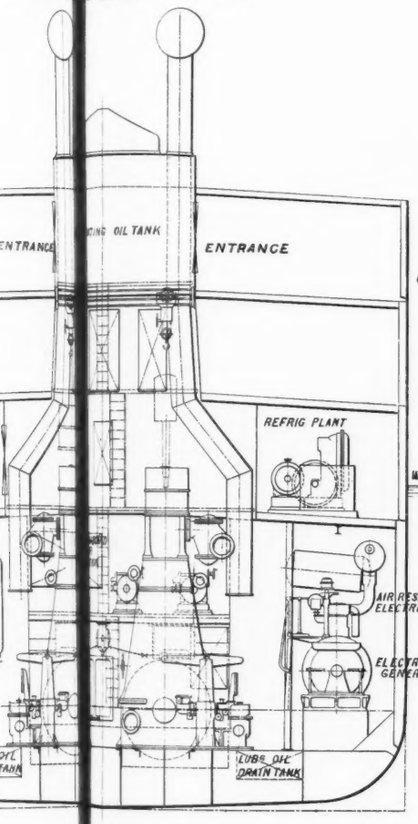
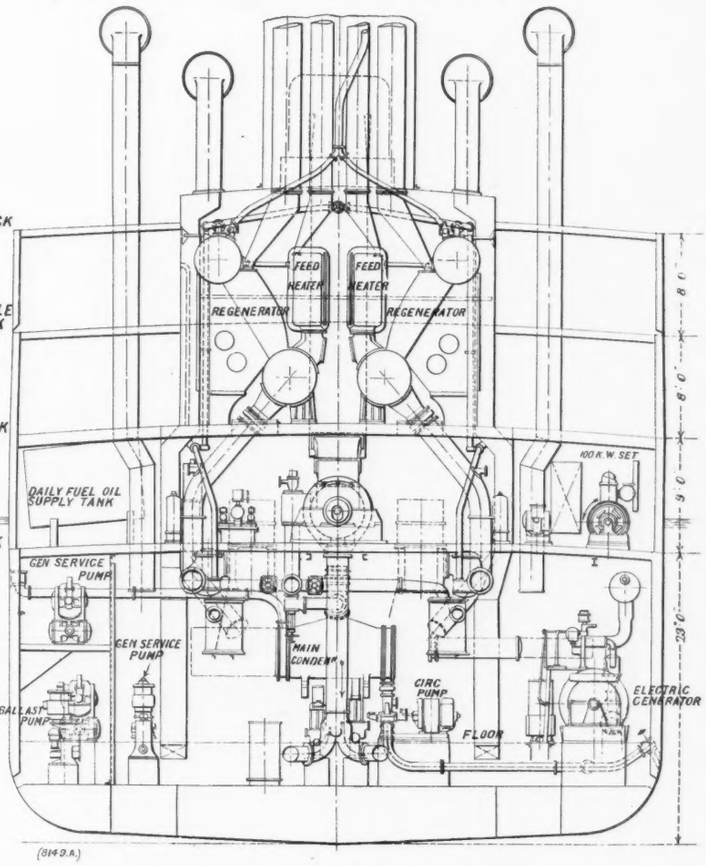


Fig. 7. SECTION AT FRAME 82 LOOKING FORWARD



PLAN AT 2ND DECK

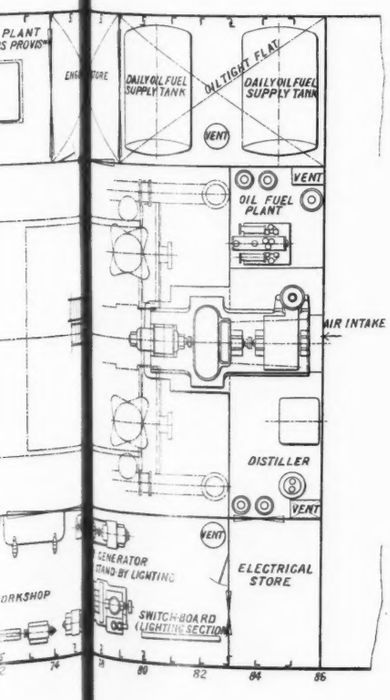
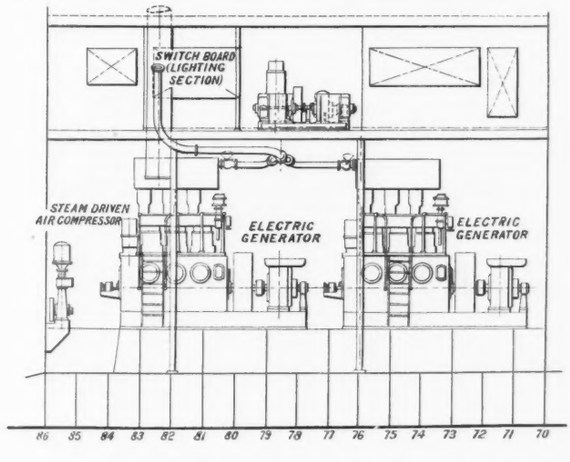


Fig. 10. ELEVATION LOOKING TO STARBOARD SIDE


SWITCH BOARD (LIGHTING SECTION)
STEAM DRIVEN AIR COMPRESSOR
ELECTRIC GENERATOR
ELECTRIC GENERATOR
86 85 84 83 82 81 80 79 78 77 76 75 74 73 72 71 70

DIMENSIONS OF MOTOR SHIP "DOLIUS."

LENGTH OF VESSEL	400 FEET.
MOULDED BREADTH	52 ,,
MOULDED DEPTH	32 ,,
DISPLACEMENT	11,650 TONS.
SERVICE SPEED...	11 KNOTS.

CYLINDER OF SCOTT-STILL ENGINE OF MOTOR SHIP "DOLIUS."

CONSTRUCTED BY MESSRS. SCOTTS' SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GREENOCK.

(*For Description, see Page* 639.)

Fig. 11.

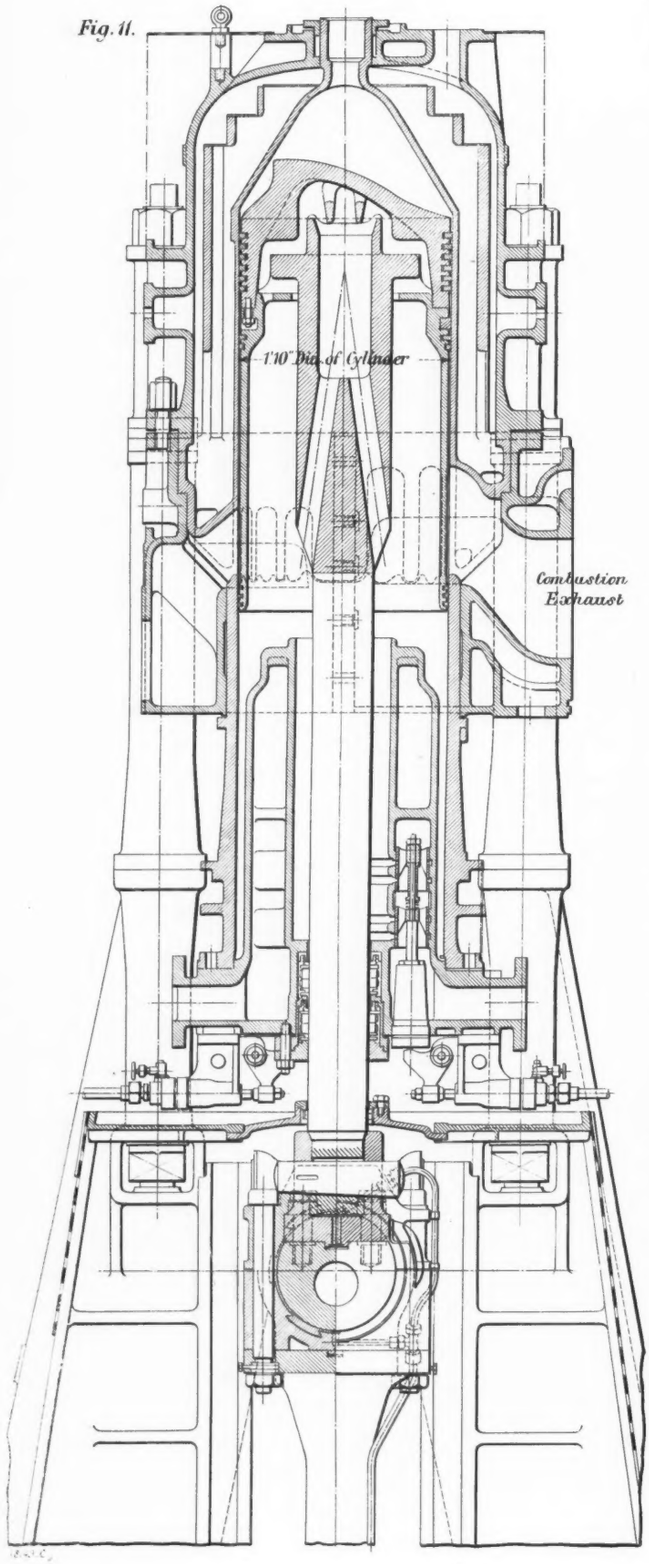
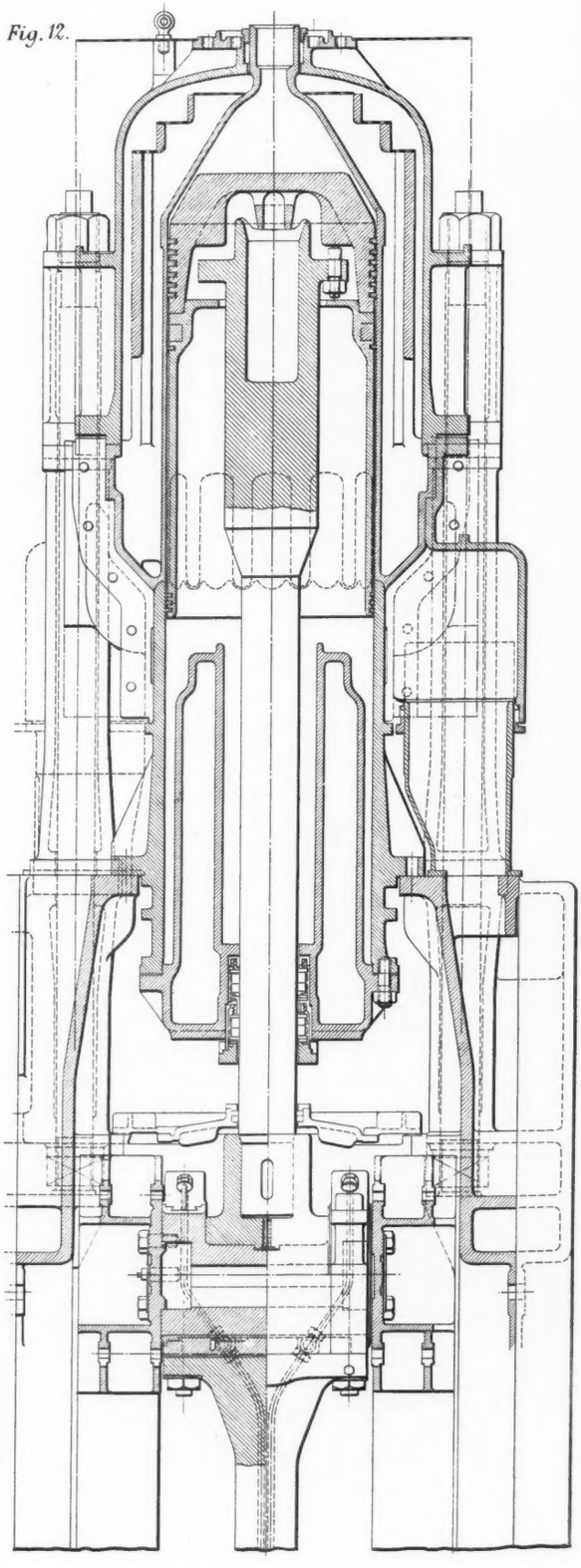


Fig. 12.



(*To face page* 641.)

ENGINEERING.

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One Two-Page Plate and Two One-Page Plates.—THE SCOTT-STILL ENGINE OF THE MOTOR SHIP "DOLIUS."

ENGINEERING.

FRIDAY, NOVEMBER 23, 1923.

THE MERCURY VAPOUR TURBINE.

LEAVING internal combustion engines out of the question, it has been taken as a matter of course ever since the days of James Watt, that steam should be the medium by which the heat of fuel is turned into work. Of all the liquids which can be vapourised by the application of heat, water alone has been utilised in boilers, and hardly a thought has been given to the employment of anything else. Water, of course, is cheap and plentiful, but the ease with which the working fluid of an engine or turbine can be conserved for use over and over again, would make these advantages relatively slight in case a better fluid were discovered. Water really holds its own because its properties are admirably adapted for the purpose in view. Its high latent heat is a positive advantage, for not only does it permit a great deal of available heat to be carried to the engine by every pound of steam, but what is more important from the standpoint of thermodynamic efficiency, most of this heat is taken in at the highest temperature. So much confusion of thought on the subject of latent heat exists in the minds of people who ought to know better, that it is worth while to make the point clear. If the maximum efficiency of an engine, working on the Rankine cycle between given steam and exhaust pressures is calculated from the data in the steam tables, and then a similar calculation is made with all conditions the same, except that the latent heat of the steam is taken at some lower value than it actually has, it will be found that the cycle will always have a lower efficiency in the second case than in the first.

The ceaseless efforts of engineers to reduce fuel consumption have resulted in higher and higher steam pressures and temperatures coming into use. If one could invent a working fluid with the exact properties desired it would be one which could be raised to the highest practicable working temperature without the pressure of its vapour becoming excessive, and it would also possess a very large latent heat. Our present materials of construction permit a limiting working temperature of 800 deg. F., or less if high pressures are associated with the temperature. Water cannot exist in a boiler above the critical temperature of 706 deg. F, and even then the pressure will be over 3,000 lb. per square inch, which is quite outside the range of ordinary practice, although an experimental boiler to operate at this pressure is being constructed at Rugby. If we take 450 lb. per square inch as the upper limit of pressure for large boiler plants, the corresponding temperature is only about 460 deg. F., at which comparatively low temperature the greater part of its heat will be given to the steam, even though the latter is subsequently raised to 800 deg. F. by superheating. These facts bring out the increasing drawbacks to the use of steam as higher temperatures and pressures are worked with. Admirable as water is for a working fluid within the range of past practice, its defects become quite noticeable as heat conditions necessary for greater efficiency are demanded, and it is of more than speculative interest to enquire whether Nature or art can present us with something which will do better.

The choice of working fluids is somewhat restricted by the conditions that they must not be injurious either to the boiler or the engine in which they are used, and that they must be stable at high temperatures. Mercury fulfils these requirements, and it has the further advantage that its great vapour density results in a comparatively low velocity when expanded through a nozzle, so that its energy may be efficiently used in a very simple turbine. These considerations led the General Electric Company of America to experiment with a boiler and turbine plant designed to work with mercury instead of steam, and last Friday evening Mr. W. J. Kearton read an interesting paper on the theoretical aspects of the question before the Institution of Mechanical Engineers. As both the paper and a report of the discussion which ensued, are printed elsewhere in this issue, we need not traverse the same ground. The ordinary engineer will be ready to accept the proposition that the vapour of mercury could be used to drive a turbine in the same way as the vapour of water, provided that the practical difficulties can be overcome. His recollection of his early studies of thermodynamics will incline him to believe that the efficiency of the cycle will be independent of the nature of the working fluid, though as was rightly pointed out in the discussion on Mr. Kearton's paper, this famous theorem is only true in the case of a perfect engine. Hence there should be no initial prejudice against the use of mercury, and the advisability of employing it instead of water will turn on the balance of advantage.

The outstanding feature of mercury is that, when raised to 800 deg. F., which may be taken as the practical working limit of temperature, the absolute pressure of its vapour is only 45 lb. per square inch. Considerations of excessive pressure do not therefore prevent the employment of a very high initial temperature, as in the case of water. But, suppose in view of the rapidly increasing volume of mercury vapour at low pressures it is decided that a vacuum of 29 in. is as high as is desirable for the mercury turbine. The mercury in this case will be finished with, so far as further work is concerned, at a temperature of over 400 deg. F. There is thus a considerable range of temperature at the lower end of the scale which cannot be utilised in the mercury turbine. We can, however, utilise the whole range from 800 deg. F. to 80 deg. F., with a corresponding increase in thermal efficiency, by using the hot exhaust mercury vapour to raise steam for the driving of a steam turbine. The mercury condenser will be constructed on the lines of a steam boiler, the "circulating water" of the condenser being transformed into high pressure steam. The specific heat and the latent heat of mercury, both being small, compared with those of water, we have to condense nine pounds or so of mercury to get one pound of high pressure steam, and there is thus a definite ratio between the power obtainable from the two parts of the system respectively.

By the use of mercury in conjunction with water, in the manner indicated, it is therefore possible to have a working range of temperature from about 800 deg. F. to say 80 deg. F., with heat entering the working fluid mostly near the upper temperature. There is of necessity an irreversible heat drop in the steam generator, but in spite of this the cycle is theoretically a good deal more efficient than any steam cycle can be. Mr. Kearton gives

in his paper a table comparing the absolute thermal efficiencies of various types of prime movers. In this table the efficiency of the mercury-vapour-steam-turbine is given as 32·3 per cent., while the ordinary steam-turbine is only credited with an efficiency of 19·54 per cent. The latter is certainly working under very moderate conditions of pressure and temperature, which prevent it making as good a showing as it otherwise might. We have heard one of the foremost living steam engineers declare positively that he would undertake to construct a steam turbine and boiler plant which would have an overall efficiency of more than 30 per cent., and this without exceeding conditions of proved safety. The record of the speaker in practical design is quite sufficient to warrant confidence in his utterances. Neither the steam boiler nor the steam turbine has yet reached its limitations as regards efficiency, and if purchasers will pay the price, the much advertised high efficiency turbine of recent continental design could be easily equalled or exceeded by any of our own designers if so costly a construction was thought to be warranted.

The technical man is disposed to think of efficiency as limited only by questions of safe temperatures and pressures, but those who have to manufacture or operate plant realise that economic facts impose very severe limitations of their own. Mr. I. V. Robinson brought out this point clearly in the discussion to which we have referred. The buyer, who after all is the final arbiter of design, wants first and foremost a plant as reliable as human skill can make it. A stoppage, even if it entails no expense in repairs to the plant, is far more feared on account of its indirect consequences, than a few per cent. extra on the coal bill. Simplicity is one of the greatest safeguards against stoppages, and improvements in efficiency which can only be obtained by the introduction of complexity of plant have to be very promising to ensure acceptance. Furthermore, any increase of efficiency in a plant is not sought for the gratification of intellectual desires, but for the prosaic reason of saving money. A saving, of say 10 per cent. of the coal bill has a definite cash value and this is the measure of its desirability to the owner of the plant. If, in order to secure it, he has to go to greater expense in labour and other operating costs, these have to be set off against the saving. If, again, the more efficient plant is more expensive, as it will almost certainly be, interest and depreciation on the extra capital cost have to be taken into account. The anticipated saving is therefore subject to deductions of a very serious nature, and while some, or all, of the extra costs are bound to be incurred, there is always the possibility that the hypothetical saving will not be realised.

In our article on the Blackburn Power Station, to which Mr. Robinson referred, it was stated that the fuel consumption of the station was reduced by nearly 10 per cent. in a few days, although no physical change of any kind had been made, and no difference in methods of operation had been ordered. The saving was brought about simply by instituting a system of records which let the operators know what results they were getting shift by shift. Within two months the coal consumption per week was reduced from 83 tons per day to 65 tons per day, although exactly the same plant was in use. When savings of this order of magnitude are possible, merely by a close attention to operating conditions aided by an intelligent analysis of the records shift by shift, ordinary station engineers will hardly think that the time has come to seek fractional increases in efficiency by venturing far outside the bounds of established practice. A simply equipped well managed station will often show a higher thermal efficiency, to say nothing of lower generating costs, than other stations working at much greater pressures and temperatures, but where less attention is paid to details. It should encourage engineers whose stations work at "obsolete" pressures to know that Mr. M. H. Adams has raised the Radcliffe station of the Lancashire Power Company to the creditable position of the third lowest in coal consumption of all the steam stations in Great Britain, although its boilers work only at 160 lb. pressure. While so much remains to be done as regards the efficient operation of ordinary steam plant, there seems little need to introduce the complications of mercury turbines.

We do not deprecate the attempts to develop the mercury turbine in any way. On the contrary we think the General Electric Company deserves the gratitude of engineers for carrying out the costly experiments which it has undertaken. In no other way could the practical data be obtained which are necessary to determine the commercial possibilities of such a plant. We are also glad that the Institution of Mechanical Engineers, whose proceedings are by no means well furnished with papers on modern prime movers, should have provided the opportunity for discussion of possible developments along the lines in question. The data tabulated by Mr. Kearton as to the properties of mercury vapour throughout a great range of pressures and temperatures will prove of great value to all investigators into the possibility of thermal gain by using mercury as a working agent. In this connection, however, the warning given by Sir John Dewrance must not be overlooked. The supplies of mercury in the world are limited, and though this metal may be purchased now at about £300 per ton in this country, a ton does not represent very many gallons, and a demand for many thousands of tons might easily put up the price to an altogether prohibitive figure, merely from the point of view of the capital which would have to be sunk in filling the boilers of a large power plant.

THE CHOICE OF A HEAVY OIL ENGINE.

Internal combustion engines using heavy oil have developed along several fairly distinct lines, and as engines of this class have come into such extended use the prospective purchaser is often considerably puzzled as to the type he should select. Questions of price, reliability and efficiency, weight and speed, all come up for consideration, and manufacturers are so numerous and their arguments so attractive that to make the best choice is by no means easy. Considering stationary engines for land purposes only, we have first what may be called the full Diesel engine, working either on the four-stroke or the two-stroke cycle with high-pressure air-injection of the fuel. We shall restrict the term Diesel to this kind of engine in accordance with historical accuracy. The next type differs from this principally in the fact that the fuel is injected by means of a pump. It may be called the airless injection cold-starting engine. The third important type, frequently miscalled the semi-Diesel engine, is the medium compression two-cycle design with hot bulb ignition. This for brevity we shall call the hot-bulb engine. There are other types of heavy oil engine in use or in more or less advanced stages of development, but those we have mentioned fairly represent the choice offered to the ordinary purchaser.

The salient facts relating to various kinds of engines were put before the Diesel Engine Users Association on November 16 by Mr. Geoffrey Porter in a paper entitled "Some Considerations Affecting the Choice of a Heavy Oil Engine." So far as fuels are concerned, it may be said that any oil one type of engine will run on, can be used satisfactorily in the other types, though slight modifications may be needed. At any rate there is not sufficient difference in the adaptability of the different engines to various fuels to make this point a matter of importance, particularly as a comparatively small number of fuels are available in marketable quantities. When using a fuel oil with a calorific value of 18,000 B.Th.U. per lb., the average consumption of a four-stroke Diesel engine at full load is given by Mr. Porter as 0·43 lb. per brake horse-power hour. This compares with 0·425 lb. for a two-stroke single acting Diesel and 0·413 lb. for a cold starting airless injection engine. The two-stroke hot bulb engine is credited with a full load consumption of 0·52 lb. per brake horse-power hour. The lowest consumption obtained within the knowledge of the author, for engines of the types named is 0·39 lb. per brake horse-power hour, a figure which has been attained both by a two-stroke Diesel and a four-stroke airless injection cold starting engine.

The latter type is said to be more economical in fuel consumption than the four-stroke Diesel, the difference in its favour being 7 per cent. at full load and 12 per cent. at half-load. The explanation given is the higher mechanical efficiency of the airless injection engine which, of course, is relieved of the work of compressing the high-pressure air. It is somewhat surprising that the difference should be so great at full load, although it is, we believe, well recognised that the airless injection engine consumes less fuel than the Diesel under power station conditions where the average load is less than the maximum. For twelve-hour continuous operating periods, four-stroke Diesels are rated up to 150 brake horse-power per cylinder, two-stroke Diesels to 600 brake horse-power, four-stroke airless injection up to 180 brake horse-power, and hot bulb engines up to 80 brake horse-power per cylinder, according to a table given in the paper. Why an airless injection engine can be built to develop more power per cylinder than an ordinary Diesel, and why the latter can only develop one-quarter the power per cylinder of a two-stroke Diesel is not at all clear, and no explanation appears to be given. There is, moreover, an historical record that a perfectly satisfactory two-stroke Diesel engine has been constructed to develop 2,000 brake horse-power in a single cylinder.

No effective comparison of the weights of engines per brake horse-power can be given unless a good many other particulars are also mentioned, but Mr. Porter gives a table from which a general idea of the weights of the various types can be gathered. Four-cycle Diesels up to 500 brake horse-power weighed from 2·42 to 3·24 cwts. per brake horse-power inclusive of flywheels. These limits of weight both related to engines of the trunk-piston type and the speed of the lighter one was 190 r.p.m., the other running 10 r.p.m. faster. A 400 brake horse-power airless injection vertical engine running at 250 r.p.m. weighed 2·07 cwt. per brake horse-power and a 300 brake horse-power hot bulb engine at 225 r.p.m. weighed 2·65 cwt. per brake horse-power. The heaviest engine in the list was a four-cycle airless injection engine of 1,100 brake horse-power running at 120 r.p.m., the weight being 3·84 cwt. per brake horse-power inclusive of flywheels.

The quantity of cooling water used on half-a-dozen engines all rated at 500 brake horse-power varied from 2·2 gallons to 11·4 gallons per brake horse-power, the temperature rise in these two cases being respectively 81 deg. F. and 23 deg. F. In the case of five engines of 1,100 brake horse-power, with oil-cooled pistons, the cooling water requirements ranged from 3·2 to 12·3 gallons per brake horse-power, the corresponding temperature rises being 60 deg. F. and 25 deg. F.

The most interesting tables in Mr. Porter's paper are those dealing with cost. The author has assumed capital to be raised at 5 per cent. and written off by sinking fund in fifteen years, the annual capital charges being thus 9·64 per cent. On this basis he gives in tabulated form the cost of operating a 200 brake horse-power engine, with a similar one as standby, for a period of 3,000 hours per annum. The engines are insured against breakdown for an indemnity equal to one-quarter of their cost. If the engines were of the four-stroke airless injection type the cost of the pair would be 4,800*l.*, and if they worked at an average of three-quarters full load, fuel at 92*s.* 6*d.* per ton would cost 0·21*d.* per brake horse-power hour, lubricating oil 0·02*d.*, water and stores 0·3*d.*, wages 0·36*d.*, maintenance materials 0·07*d.*, and capital charges 0·32*d.* per brake horse-power hour, the total cost amounting to 1·01*d.* per brake horse-power. Four-stroke Diesel engines would cost 6,000*l.* and with all items as above except slightly greater capital charges, the operating cost would be 1·07*d.* per brake horse-power hour. Two-stroke hot bulb engines would cost 3,400*l.*, and although their fuel and lubricating oil charges would be increased to 0·27*d.* and 0·07*d.* respectively, the reduction in maintenance charges and interest would bring the total generating costs to 1·01*d.* per brake horse-power or the same as the engines first considered. Corresponding figures are given by the author for full-load, half-load and quarter-load working, but we only quote the

three-quarter load figures, as they best represent average practice.

Another table gives an analysis of the cost of running a 1,500 brake horse-power heavy oil engine plant, for 3,000 hours per annum at three-quarters of the rated load. If the plant consisted of three 500 brake horse-power four-stroke trunk type Diesels, costing 22,500*l.*, the total generating cost is given as 0·60*d.* per brake horse-power hour, of which 0·23*d.* is for fuel costing 92*s.* 6*d.* per ton, 0·01*d.* for lubricating oil, and 0·20*d.* for capital charges. With an equipment of slow speed two-stroke Diesels of 750 brake horse-power each costing 18,000*l.*, the fuel and lubricating costs are put at 0·21*d.* and 0·013*d.* respectively, the total cost being 0·533*d.* per brake horse-power. Three hot-bulb engines of 500 brake horse-power each, costing 12,750*l.*, would have a fuel cost of 0·27*d.*, a lubricating cost of 0·08*d.* and a total cost of 0·61*d.* per brake horse-power. Four airless injection engines of 400 brake horse-power would cost 19,200*l.* Their fuel and lubricating costs would be 0·21*d.* and 0·02*d.* respectively, and the total cost 0·54*d.* per brake horse-power hour.

Mr. Porter thinks that in the case of the 200 brake horse-power plant first mentioned, there is little doubt about the best selection. All types can be relied on to give satisfactory service, and in view of their equal cost the cold starting airless injection engine is to be preferred for practical reasons over the hot bulb engine. Mr. Porter appears to be driven to the conclusion he arrives at with a certain amount of regret in view of the high practical efficiency to which the Diesel engine has been developed. He sees no real objection to the high-pressure air compressor which gives little trouble in use. Capital cost is the decisive element, and according to the figures given the Diesel engine will cost 112*l.* per annum more than either of the other types at three-quarters of its rated load. In capacities of over 1,000 brake horse-power, Mr. Porter considers that the two-stroke Diesel engine will survive against all rivals, and he gives his reasons for this opinion. In such sizes the four-stroke Diesel becomes exceedingly heavy and large, and even now the two-stroke engine can be built for cylinder ratings nearly double those of its rival. It is moreover a vastly simpler engine mechanically, and is fully as efficient with respect to fuel consumption as the four-stroke engine.

THE SCIENTIFIC AND INDUSTRIAL RESEARCH DEPARTMENT, 1922–23.

(*Continued from page* 584.)

THE third part of the Department's report deals separately with the work of its Research Boards and Committees. Some part of this has been published during the year, and accounts have accordingly appeared in these columns, details of which need not be repeated here. The researches mentioned below, numerous and varied though they are, form only a part of the activities of the bodies concerned during the year.

Fuel Research Board.—In addition to the setting of horizontal steel retorts put in for conducting low-temperature carbonisation on a works scale (see page 168 *ante*), new vertical retorts, based on Scottish shale oil practice, have now been designed and installed for the same purpose. The present scheme is to carbonise briquettes made of a blend of caking and non-caking coals heated to a temperature below their decomposition point and then subjected to pressure without any binder. These retorts are now at work, but have not been so for long enough to warrant any conclusions. Some preliminary work at low temperatures was done in the old vertical retorts, put in for high temperature carbonisation (see page 212 *ante*).

Early in the year under notice it was found desirable to renew the lining of these retorts, and incidentally the cast-iron linings and shutters of the sight holes were replaced by fireclay plugs. The result has been a saving of fuel gas for heating the retorts to the amount of about 3 therms for the four retorts, or approximately one-third of the entire loss through radiation from the setting, including the pre-heater. This indicates a surprisingly high order of magnitude for the saving to be made by substituting fireclay for iron fittings, and suggests that heat losses by radiation, &c., in other ways may repay attention.

While this work was going on some comprehensive tests were made on the efficiency of water-gas plant under various conditions (see page 195 *ante*), and a variety of smaller scale work, including tests on the combustion of coke, CO_2 recorders, the Thomas recording calorimeter and tetralin and tetralin-petrol mixtures for motor-car engines. Experiments have also been made with a view to developing a producer gas plant for the Colonies to work with charcoal, and into the carbonisation of sea-weed with a view to the possibility of reviving the Atlantic coast seaweed industry. The first section of the Board's annual report, dealing with air-dried peat, has already been noticed (ENGINEERING, vol. cxv, page 808).

The Board's work on the physical and chemical survey of the national coal resources continues to extend. The Lancashire and Cheshire Survey Committee formed in co-operation with coal owners has been collecting further data, which now give a fairly exhaustive account of two of the most important seams in the area, and the purely laboratory examination of samples has been supplemented at the Fuel Research Station both by large-scale work in the retorts and by special tests on a few hundredweights. A similar committee has now been formed for the South Yorkshire area, on which the Board is also represented. The microscopical examination of seams continues to be done by the Lomax Palæobotanical Laboratories.

The Committee on Sampling and Analysis of Coal on the basis of experimental work extending over the last eighteen months has now reported on the best methods of analysis, which henceforth will be adopted by the Board, and, it is hoped, by other workers, so as to make analysis by different investigators more comparable than they have been hitherto. The Committee is now to become a Standing Committee of the Board, with a view to taking account of further knowledge as it becomes available, and still has the difficult question of sampling to deal with (see page 626 *ante*).

Dr. Margaret Fishenden is continuing directly under the Board at the Westminster Technical Institute the work she began at Manchester on domestic heating, and it is hoped to obtain definite data of the influence of the several factors on warmth, comfort and cost. In the meantime it may be suggested to the Department that as yet "warmth" and "comfort" are not adjectives in the English language, and it may be hoped that in its future publications it will not defile the well of official and scientific English by neologisms derived from the American advertisement dialect. With the help of a further grant from the Board to the Manchester Corporation Air Pollution Advisory Board, Mr. F. S. Sinnatt is continuing for that body his work on the waste gases and soot of coal fires, in which preliminary work indicates that a loss of as much as 25 per cent. to 30 per cent. of the heat value of the coal may be incurred.

Work on the production of power alcohol is proceeding in various directions. In its production by fermenting the pentoses resulting from the acid hydrolysis of cellulosic materials the mechanism is now well established for yielding the maximum of pentoses with a very low strength of acid and at a moderate temperature and pressure; while a number of experiments both on the laboratory and semi-technical scales made with wheat straw and African grasses have shown that hydrolysis when carried too far generates substances inhibitory to fermentation, and that additions to the mash indicated in the original American experiments are in fact unnecessary, and have indicated close limits for the optimum hydrogen-ion concentration. The fermentation produces about 85 per cent. of ethyl alcohol and 15 per cent. of acetone. No conclusive results have been obtained so far in the work on the direct fermentation of cellulosic materials by means of micro-organisms.

The production of alcohol on a commercial scale for use as an ingredient of liquid fuel has been begun in this country, and Dr. Ormandy and Mr. E. C. Craven with the assistance of the Department have continued their work on the physical properties of mixed fuels. The Board's second memorandum on fuel for motor transport which was circulated to the Dominions and Canada in 1921, has elicited a considerable number of replies, which are summarised in the report. It appears from these that a considerable amount of experiment or manufacture on a small scale is going on with the object of producing alcohol from waste products or from suitable crops, though some replies consider that suitable crops are more likely to be used for food.

The National Physical Laboratory.—A full account of the activities of the National Physical Laboratory was given so recently in ENGINEERING (vol. cxv, page 809 and following numbers), that the less detailed particulars given in the report under notice add little to them.

Food Investigation Board.—Though its equipment is by no means completed, the Food Investigation Board's Low-Temperature Research Station at Cambridge began work during the year under notice. Its design has been based on the conviction that the standard of accuracy on which commercial practice is founded cannot be too high; a view of which the soundness would be realised more constantly than it is if it were remembered that every variable which can be accurately controlled leaves one less to perplex industry. With this conviction in mind the Station has succeeded in designing and equipping four chambers in which a temperature constant within 0·05 deg. has been maintained over long periods; a degree of accuracy that previously, as the report states, could only be obtained on a small scale in incubators, and it may be added was often lacking even in them. The purpose of the station is to conduct researches on the effect of cold on animal and vegetable tissues, and in the process of carrying out work on these subjects for the various committees of the Board it has sought to take its part to mutual advantage in the general scientific work of the University, and to place its peculiar facilities for low-temperature investigations at the disposal of workers in other laboratories. Up till now 35 research workers from various University laboratories have made use of it, and some of them have already obtained important results.

The Fruit and Vegetables Committee has in hand an intensive study, which will extend over many years, of the physiology of ripening of individual fruits, both under normal and storage conditions, and of the diseases to which such fruit is liable. As has already been seen in these columns (see page 180 *ante*), the Committee's policy of pursuing a plan of general and fundamental research instead of waiting upon occasion, has already been justified in respect to a disease of apples, involving the damage of large quantities; for the work that had already been done enabled the disease to be identified immediately and effective treatment prescribed. The work may be expected, moreover, not only to provide in advance the solution of individual problems before they arise in practice, but also to help in the elaboration of the general theory of the freezing of tissues, in which the solution of many problems may lie. Thus in experiments with eggs it has already been discovered that preservation—presumably without injury to the tissues—depends on the rate of cooling falling within certain limits. Changes observed on freezing are reversed on thawing when these limits are observed, but are irreversible when they are exceeded; and the translation of this result into practice will doubtless give rise to interesting engineering problems.

The Fish Preservation Committee has been at work successfully on changes occurring in and after brine freezing, and the Meat Committee on the chemical changes occurring autolytically in meat during chilling and at the lower temperature used for freezing, as well as on the relation of chemical changes produced by bacteria to the various phases in their growth.

The Fruit and Vegetables Committee carried out a large scale gas storage trial in the Histon Gas Store, as the result of which the apples sold after storage for over twice their value when received into store. The trials also confirmed previous conclusions as to the effect of the method of packing on the state of the fruits. Commercial cold storage tests were continued at the Port of London Authority's Cold Store, at the Low Temperature Station, and at the

Experimental Station at Long Ashton. Scientific work done for the Board at the Imperial College of Science and Technology, and elsewhere, has thrown light on the chemistry of ripening, the storage properties and respiratory activity of apples as affected by their cultural conditions, and parasitic diseases of apples as started with physiological disease in the openings of the fruit's minute respiratory tubes.

Under the Oils and Fats Committee work has been continued at the Victoria University, Manchester and the University, St. Andrews, on the higher chemistry of oils and fats, and at the Lister Institute, on the production of fat by the yeast plant. The chemistry of canned fish has continued to be investigated at Cambridge for the Canned Foods Committee, and several reports by Dr. W. G. Savage have been published on his work for the Board on the bacteriology of canned foods.

Geological Survey Board.—Seven field units have been engaged on primary 6-in. surveys of the London and South-Eastern, Midland and North Wales, and South-West and North Highlands areas, and on the coalfield revision of the Ayrshire, Central Scotland, Northumberland and Durham, Cumberland, and Lancashire areas. Further special reports have been issued on the mineral resources of Great Britain (barytes and witherite, lead and zinc in certain districts, and cannel coals, lignites and mineral oil in Scotland). A memoir has been published on the water supply of Cambridgeshire, Huntingdonshire and Rutland from underground sources, and similar memoirs dealing with Wiltshire, Gloucestershire and Dorsetshire are in preparation. In the Museum of Practical Geology special attention has been given to the arrangement and display of British economic minerals and rocks, such as fireclays, abrasives, ganister, silica rocks, roadstones, and iron ores.

Forest Products Research Board.—The Board is still engaged on collecting and correlating information already available, in preparing a census of the problems that fall within its scope, and on instituting and maintaining due liaison with organisations at home and abroad having similar interests and with the various wood-using industries. In its view the economic and efficient conduct of research depends largely on the completeness with which this necessarily slow process is carried out.

Considerable progress has been made in fundamental laboratory work dealing with the relations of water to wood, for which the Board has set up under its own direct control a suitable research station at the Royal Aircraft Establishment, Farnborough. The seasoning plant is designed to consist of a laboratory, a constant temperature and humidity room, a battery of three Tiemann water-spray kilns (one of average commercial dimensions and the other two of semi-commercial size), a small model kiln of laboratory size, and a steaming cylinder. With these will be investigated such subjects as hygroscopicity, movement of hygroscopic water in and out of wood, movement of water within wood, shrinkage, and swelling and warping, with the object of working out fundamental laws of drying wood. Studies will also be made of the effect of variations of temperature, humidity and air circulation, by which correct schedules may be drawn up for the artificial seasoning of the various classes of timber. The chemical and other effects of various natural and artificial treatments will also be investigated, such, for instance, as the action of steaming in eradicating warping and twisting, the sterilisation of timber, and its mechanical values under different treatments. Kiln design is also to be studied.

The Board is taking steps to initiate research at Farnborough into the mechanical testing of timber. In its view, however, the extent to which the results of such research can be applied in practice must depend largely on how far the scientific knowledge necessary for interpreting them can be obtained. Much of the work will doubtless have a speedy practical application, but the Board's view as to the need for adequate scientific knowledge for the interpretation of mechanical results is supported strongly by the history of mechanical metal testing, in which even now no agreement has been reached between the vast complexity of tests and the structure and life history of the metal to which they are applied. It is the Board's hope, as the progress of the research indicates the directions that are appropriate, to enlist the help of other organisations in investigations bearing more directly on technical applications.

It is hoped that in the near future concerted action, initiated by the Board in conjunction with other institutions, will be taken in research into problems of dry rot. Satisfactory results have already been obtained in an investigation into the prevention of dry rot in the wooden insulation of cold stores. Work has been begun on the chemistry of timbers, a wide and complex subject of fundamental importance to much of the Board's work. The Board is considering what additional aid it can give to research on tannins, natural dyes, and turpentine oils, in particular with the object of providing an Empire-grown substitute for the foreign quebracho as a tanning material, and to the use of natural dyes in colouring foodstuffs. Investigations are also being made into means of softening certain timbers, to enable them to replace the foreign supplies now used in pencil making.

(To be continued.)

THE NEW WORKMEN'S COMPENSATION ACT.

If the above named Act, which received the Royal Assent on the 16th inst., and will come into force on January 1, does not satisfy Labour, it nevertheless effects a great many improvements from the point of view of the workers in the law of workmen's compensation, and, as the Home Secretary remarked in his speech on the third reading of the Bill, it is a very curious thing that although the Bill was alleged to be unsatisfactory, the leaders of the Party begged the Prime Minister to give time for the passing of the Bill before Parliament was dissolved. It may be useful to examine in outline the main provisions of the Act.

The Workmen's Compensation War Addition Acts are to cease to have effect after December 31, except as regards accidents occurring before that date, but what the workmen lose on the swings they gain on the roundabouts. The maximum total amount of compensation payable in the case of death is raised from 300*l.* to 600*l.*, and where the worker leaves a widow, or some other member of his family over the age of 15 years, and children under 15, the amount of the compensation payable under the Act of 1906 is to be increased so as to make a special provision for the young children until they reach the age of 15. This is an entirely new departure from the principle of the former Acts, in which the compensation was based on the loss of earnings without reference to the number of the deceased worker's dependants. There were many arguments against such a departure from the principle, but in the end the humanitarian view prevailed.

Under the former Acts the minimum payment in the case of death to those who are wholly dependent on the workman's earnings was 150*l.* In future it is to be 200*l.*

In the case of weekly payments during total incapacity the maximum payment under the former Acts was 1*l.*, but this is raised to 30*s.*, and where the weekly incapacity payment would amount to less than 25*s.* there is a special provision under which the amount is to be increased. The Labour Party clamoured for the 66⅔ per cent. of the wages which was proposed in the Holman Gregory Report, but, as Mr. Bridgeman has pointed out, the lower-paid workers will in some cases get more than that. A man earning 60*s.* a week got 20*s.* under the 1906 Act; he will now get 30*s.* The man who earns 50*s.* now gets 25*s.*; the man who earns 40*s.* now gets 22*s.* 6*d.*; the man earning 30*s.* got 15*s.* under the 1906 Act, but now he will get 20*s.*; the man who earns 25*s.* got 12*s.* 6*d.* under the old Act, as against 18*s.* 9*d.* under the new; and the man who earns 20*s.* will get 15*s.*, which is 75 per cent. of his wages. Subject to the provisions in favour of the lower-paid workers, the principle that the compensation should be based on half wages has been retained. In the case of partial incapacity there are some modifications in favour of the workers.

In committee, battle raged over the waiting period. The Labour Party wished to abolish it altogether, but the employers, in order to avoid claims for compensation for trivial accidents, wished to retain some waiting period. It has been reduced to three days except where the incapacity lasts for at least four weeks. In that case compensation is to be payable from the date of the accident.

Another departure from principle is involved in the inclusion of certain accidents arising outside the scope of the employment. As is well known, the Act of 1906 swept away the defence of serious and wilful misconduct in the case of death or serious and permanent injury; but in some cases the employers maintained successfully that where the worker had done something which he was forbidden to do and had thereby been killed or injured, he had gone outside the scope of his employment and the accident did not arise out of, and in the course of, his employment, and compensation was not payable. It was urged that this resulted in hardship to the workers or their dependants, as in many cases the worker, although breaking the rules, did so in what he conceived to be the interests of his employers. Mr. J. H. Thomas instanced the case of the locomotive driver who is killed or injured through going forward from the footplate while the train is running, rather than stop the train. An accident resulting in death or serious and permanent disablement is now to be deemed to arise out of, and in the course of, the employment, notwithstanding that the workman at the time of the accident was acting in contravention of a regulation or of his employers' orders or without instructions, if his act was done for the purposes of, and in connection with, his employers' trade or business. We fear that there will be much litigation over this clause.

Under the Act of 1906 "workman" does not include any person employed otherwise than by way of manual labour whose remuneration exceeds 250*l.* a year. It may now include persons whose employment is of this character, provided their remuneration does not exceed 350*l.*

As regards the notification of accidents a number of improvements have been made. Under the Act of 1906 it was the duty of the injured worker to give notice of the accident as soon as practicable, and unless he did so he might, in some circumstances, be barred from taking proceedings; but now a book is to be kept at every factory, in which particulars of the accident may be entered by the injured worker or some other person on his behalf, and an entry in the book is to be sufficient notice of the accident. Further, the want of notice is not to be a bar to the maintenance of proceedings if the employer is proved to have knowledge of the accident from some other source at or about the time of the accident, or if the injured man has been treated in an ambulance room at the factory. These provisions seem reasonable.

The provisions with regard to medical referees have been improved. At present, where a workman has been medically examined and the medical report is disputed, the Registrar of the County Court may refer the matter to a medical referee on the application of both parties. In future this may be done on the application of either party (the workman or the employer), subject to appeal to the County Court Judge; but where the application is made by only one of the parties, the Registrar or the judge, if of opinion that the matter ought to be settled by arbitration, is to refuse to allow the reference to the medical referee.

The powers of the registrars and judges of County Courts have been greatly strengthened with regard to the registration of agreements for the payment of a lump sum. They may require the parties to furnish them with information, or even to attend before them; and if the information as to the workman's condition appears to be insufficient or conflicting they may require a report as to the workman's condition to be obtained from a medical referee. If it appears from the report that the prospects of the workman's recovery cannot yet be approximately determined, the registrar, or on appeal the judge, may refuse to record the memorandum. The object of this is, of course, to prevent workmen being induced to settle their claims for compensation for the payment of an inadequate lump sum. Another interesting provision is to the effect that such agreements are to disclose the amount of costs, if any, paid or payable by the employer to the workman's solicitor. If the registrar considers the amount excessive he may have the bill of costs

taxed, and if the amount is reduced on taxation the amount of the reduction is to be applied for the benefit of the workman or his dependants or paid to the employer or otherwise dealt with as the judge may direct.

One of the workers' grievances under the Act of 1906 was that the employer, after making weekly payments for some time, could stop or diminish them if there were no registered agreement, and the workman had either to submit or to take legal proceedings. In future the employer cannot do this except in certain cases, viz.: (*a*) Where the workman has actually returned to work; (*b*) where the weekly earnings of a partially incapacitated workman have actually been increased; and (*c*) where a medical practitioner has certified that the man has wholly or partially recovered or that the incapacity is no longer due to the accident. In this last case the employer is to send a copy of the medical certificate to the man, with notice of his intention to end or diminish the payments after ten days. If the workman can obtain a medical report disagreeing with the employer's report he may send it to the employer within the ten days, and if that is done the weekly payment is not to be ended or diminished except in accordance with the workman's medical report or in accordance with the report of a medical referee. In the meantime the weekly payments are to be paid into court. This is in effect a compromise. The Labour Party claimed that the payments should be continued, but the employers objected to having to continue, in disputed cases, to make payments which they would never be able to recover if it should turn out that the man had recovered and that their proposal to end or diminish the payments was justified.

There are new provisions for the reviewing of weekly payments on fluctuations of weekly wages, and many other minor amendments. There are also provisions as to the notification of accidents, which are to be read along with the Notifications of Accidents Act, 1906, and certain requirements as to the provision of first-aid boxes, which are to be read along with the Factory and Workshop Acts. Without in any way objecting to these provisions, we think it is unfortunate that they have been included in a Workmen's Compensation Act instead of being passed in separate Acts. Factory provisions should be made in factory Acts and should not be tucked away in Acts dealing with other matters. In any event, the new Act contains so many modifications on the existing Workmen's Compensation Statutes that it is imperative that the law on the subject should be codified.

NOTES.

Regulations for Overhead Lines.

Early in 1922 representations were made to the Electricity Commissioners by the Incorporated Municipal Electrical Association on the subject of the relationship between the electric supply industry and the General Post Office, particularly with reference to the question of protection as between overhead and underground mains belonging respectively to authorised undertakers and the Postmaster General. In view of this a conference was called by the Commissioners in August of last year, at which the various parties interested were represented, and as a result of that conference and after consultation with a special committee appointed by the Institution of Electrical Engineers, the Commissioners have prepared and published a revised set of "Regulations for Overhead Lines." The regulations are in fairly general terms and allow all the latitude that a designer is likely to desire. Line conductors of copper, aluminium or such other materials as may be approved by the Electricity Commissioners are allowed. The minimum cross-sectional area of copper which may be used is 0·0098 square in. and of aluminium 0·0237 square in., the respective weights per mile of these sizes being 200 lb. and 147 lb. All material both for lines and poles must comply with the specifications by the British Engineering Standards Association. The factor of safety of line conductors is specified to be 2 and to be calculated from the breaking load, and on the assumption that they are at a temperature of 22 deg. F. and covered with ice, of a radial thickness of ½ in. in the case of conductors for voltages not exceeding 650 volts for direct current, and 325 volts for alternating current. For voltages exceeding these a coating of ice ½ in. radial thickness is to be assumed. A wind of 50 miles an hour blowing at right-angles to the line is to be allowed for, and is to be taken as exerting a pressure equivalent to 8 lb. per square foot of projected area of the ice-covered lines. The weight of ice is to be taken as 57 lb. per cubic foot. The regulations are specific on questions of earthing and arrangements in connection with road crossing, &c. The minimum height of conductor specified is 20 ft. at temperatures below 122 deg. F. The height holds for pressures up to 66,000 volts. For higher voltages the height is to be increased reaching 23 ft. at 165,000 volts. Copies of the regulations may be obtained through the usual channels at 2*d.* each.

Empire Electrical Development.

The growing importance of electrical methods in the engineering field is well shown by the fact that in the period of depression through which we have been passing, electrical manufacturers have in general been able to maintain their shops in a state of activity considerably better than the general average. The extension of electrical operation on railways, the growth of power stations and the conversion of factories to electric driving have proceeded at a very fair rate even when many branches of engineering have come almost to a standstill. There are no indications of any slackening of work of this kind in the near future, and the outlook for our electrical manufacturers is very promising. None the less it is well to remember that Great Britain is a comparatively small island, and for a proper development of our electrical manufacturing possibilities it is essential that a very large overseas trade should be built up. The whole country is at the present time looking particularly towards the Dominions as a field for electrical enterprise, and the Prince of Wales, in proposing the toast of "Imperial Trade and Resources," at the dinner of the British Electrical and Allied Manufacturers' Association, on the 15th inst., certainly indicated one of the great future fields for British electrical materials when he referred to the great water power resources of the Empire which are awaiting development. This dinner, which was held under the chairmanship of the Earl of Derby, the president of the association, was a remarkably successful function, and must have impressed many of the Overseas visitors who were present with the importance and extent of the British electrical industry. The total attendance at the dinner was some 700, the numbers probably being swelled this year by the Overseas visitors and the large number of guests who were connected in some way with the organisation of the British Empire Exhibition to be held at Wembley next year. As will be generally known the British Electrical and Allied Manufacturers' Association is taking a very prominent part in this exhibition, having taken over the organisation of the whole electrical section and of the World's Power Conference which is to be held at Wembley in the course of the run of the Exhibition. A pleasing and novel feature of the dinner, in keeping with the Empire atmosphere, was the decoration of the tables with native plants from the Dominions and Colonies. The procedure which was both interesting and effective had been made possible by the co-operation of Dr. Arthur W. Hill, the Director of Kew Gardens, who himself was among the guests present.

The Belin System of Telephotography.

This process, due to M. Edouard Belin, which has been attended with a large measure of success, was described by the inventor in the course of a lecture on "Telephotography, Teleautography and Television," before the Royal Society of Arts, on Wednesday, November 14. In it the photograph employed is printed in relief, and the varying height of the picture is communicated to the diaphragm of a sensitive microphone. Varying currents are passed through the microphone in consequence, and these are sent to the receiving instrument for use in reproducing the picture. For that purpose a Blondel oscillograph is used and the changing currents cause a greater or less tilt of the mirror. Light from an electric lamp is reflected from the mirror, and the deflection it shows depends on the momentary magnitude of the current which, as we have seen, is dependent on the height of the print at any point. As the reflected beam of light is swept to one side, it passes through a screen of varying density. This at one end is opaque and at the other is transparent and there is a gradual variation in the degree of opacity from one end to the other. At whatever point on the screen the beam of light touches, an amount of it, depending on the tint of the screen at that point, will pass through. This is concentrated by lenses to a point and is used as the exposure for a moment on a sensitised film. Both the drum on which the photograph is placed and the receiving drum, are revolved and at the same time advanced along the longitudinal axis. By that means a continued series of light impressions is made on the film, and their intensity depends on the relief of the original photograph, and thus the new photograph is built up. Unless the two drums, transmitting and receiving, are made to revolve in synchronism no satisfactory result could be obtained, but the difficulty is got over by making the receiving cylinder stop at the end of each revolution until the transmitting one is in the same position. This is effected by a pawl and ratchet on the drive to the receiving drum. They are disengaged when current is passed along the line through a contact maker at the transmitting end at the completion of each revolution. This current operates an electromagnet which pulls the pawl out of engagement and leaves the drum free to turn another revolution. When the matter to be transmitted is simple line work, such as drawing or handwriting, the microphone is replaced by a contact breaker and the screen at the receiving end is not required, as no gradation in density is desired. The system may be used in association with wireless transmission and actually autograph messages have been sent from America to France by that method. Examples of transmitted photographs, drawings, longhand, shorthand, Chinese writing and printing were thrown upon the screen at the Royal Society of Arts lecture, and a successful demonstration in transmitting a photograph of the Prince of Wales was given. Proposals regarding a scheme for television were described by M. Belin at the end of his lecture.

The Volumetric Measurement of Coal.—At a meeting of the Electrical Power Engineers Association held in the building of the Institution of Electrical Engineers on Friday evening, November 2, a lecture on "The Volumetric Measurement of Coal in Relation to Power Station Problems" was delivered by Mr. Jas. E. Lea, B.Sc., M.I.Mech.E. Mr. Lea emphasised by means of actual experiments on many different sizes of coal, the fact that a given volume of screened coal always weighed the same, within very small limits, whatever the size of the coal was. A hopperful of large nuts, for example, will weigh substantially the same as a hopperful of small pea coal. This fact depends upon the average geometrical similarity of the small and large pieces, and is not generally appreciated by engineers. It, however, makes it possible to ascertain the weight of coal burnt with practical accuracy by the measurement of its volume, and this principle has been taken advantage of in the Lea coal meter, which has come largely into use in power stations, for measuring the coal consumed on chain-grate stokers.

The Cathodic Behaviour of Iron-Nickel Alloys.—Dr. S. Glasstone, of University College, Exeter, presented a paper on "The Cathodic Behaviour of Alloys," to the Faraday Society on November 12. He is engaged in a systematic investigation of the electrochemical behaviour and polarisation voltages at electrodes composed of metallic alloys, and he dealt in this paper with iron-nickel alloys. Such alloys can be prepared in various ways, metallurgically by fusing the metals together when uniformity of composition is difficult to secure, or chemically or electrolytically by precipitating or electrolysing mixtures of salts of the two metals. The alloys will differ from one another, generally and electrochemically, according to the mode of preparation, the rate of diffusion being especially important for the electric phenomena, as Tammann pointed out in 1918 in an interesting memoir presented to the Gesellschaft der Wissenschaften, Göttingen—a publication hardly accessible over here now. Studying potentials and the influence of polarisers under varying conditions, Dr. Glasstone finds that mixtures of iron and nickel are deposited from mixtures of their sulphates at much lower potentials than either of the pure metals, and that the deposits contain relatively more iron than do the baths. Hydrogen is also evolved at lower potentials than at either of the two metals. In the reduction efficiency of a particular electrode, the electrode itself seems to be able to exert a catalytic effect; it is not simply a question of the over-voltage of the hydrogen.

THE COMMERCIAL MOTOR TRANSPORT EXHIBITION AT OLYMPIA.

THE value of the periodical exhibitions of commercial motor vehicles organised by the Society of Motor Manufacturers and Traders, lies very largely in the part they play in educating the public to the possibilities of mechanical transport. The exhibition which opened at Olympia yesterday is in no way behind its predecessors in interest, and serves to show in a small compass the principal improvements which have taken place in motor traction since the last show was held in 1921. If it serves to quicken the interest of the users of road transport in questions of economical service the purpose of the show will be accomplished and an increase in motor carrying may be anticipated. It is invariably the case that whenever a firm has investigated the cost of road transport the use of motor vehicles is resorted to and, this being the case, the only feasible conclusion is that those who still make use of antiquated, slow and costly means of haulage run their businesses in a haphazard way and therefore do not realise the transport costs they are incurring. Looked at from the standpoint of those who are endeavouring to obtain economic working, the presence of horse haulage in the busy streets of our large cities is much to be regretted. When the roads are narrow and possibly further restricted by the presence of tramways running on fixed track, the transport speed must be reduced to that of the slowest moving vehicle, the horse-drawn lorry. If frequent stops take place the slow acceleration of the horse vehicle is the cause of an addition to the trouble. Were all the traffic in such streets motor propelled, the speed of transport could be greatly increased and a great financial gain obtained. As the circumstances are at present, there is no question that economy may be shown by the use of motor vehicles over horse propulsion in almost every type of work.

One interesting development which is shown in this exhibition is the attempt to produce a reliable and cheap delivery van of British manufacture. This effort, the result of the application of production methods in the workshops, must be commended. It was greatly to our discredit that there was formerly little or no British competition in this large and important field. Now that there are tangible signs of the awakening, it is the pleasant duty of those who are interested in the development of British trade to call attention to them. This enterprise, of Morris Motors, Limited, in particular, cannot be allowed to pass unnoticed, and the study of the design and construction of these light delivery vans will convince the visitor to this exhibition of the success which has attended their efforts.

In the sphere of heavy vehicles, whether steam propelled or driven by internal combustion engines, the home products have always been held in high esteem for their sturdy design and their reliability. The machines of this class on show at Olympia will enhance that reputation. There is one class of vehicle of this type which deserves special reference, the petrol motor 'bus. Within the London area these are rendering a great service in dealing with the carrying of city workers, but outside that district the application has been much more restricted than the merits of the system deserve. There is little doubt that this form of passenger conveyance has much to recommend it. The necessity for expensive overhead or conduit cable systems and track construction are disadvantages which are associated with the tramway car. There is no equivalent for these in a motor 'bus system, while there are also great advantages in flexibility in traffic and freedom from following a prescribed route, when deviation is advisable. Extended use will be found for motor 'buses in many of the towns of this country when the economic possibilities are more appreciated. Certainly the congestion in the streets of large cities where tramways are installed could be much reduced by their replacement by a service of 'buses.

Conferences are to be held during the run of the exhibition at which various questions relating to motor transport will be discussed. The subject for consideration at a meeting on November 26, organised by the Incorporated Association of Retail Distributors, will be "Relation of Transport to Retail Distribution." On the following day papers

12-TON TIPPING WAGON AT OLYMPIA.

CONSTRUCTED BY SCAMMELL LORRIES, LIMITED, LONDON.

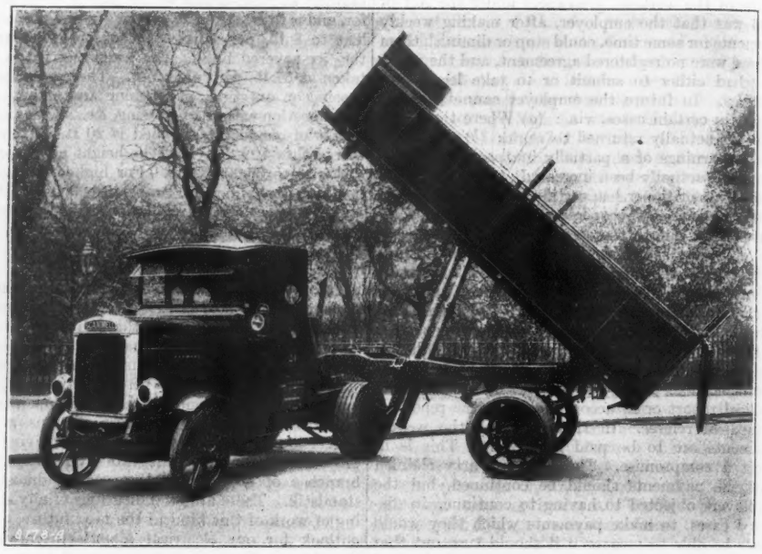


FIG. 1.

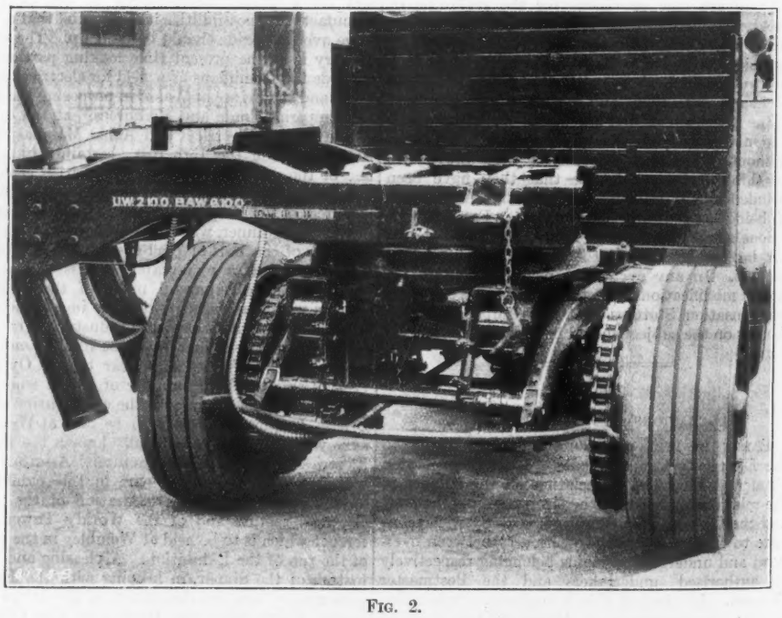


FIG. 2.

FIG. 3.

EXHIBITS AT THE COMMERCIAL MOTOR SHOW AT OLYMPIA.

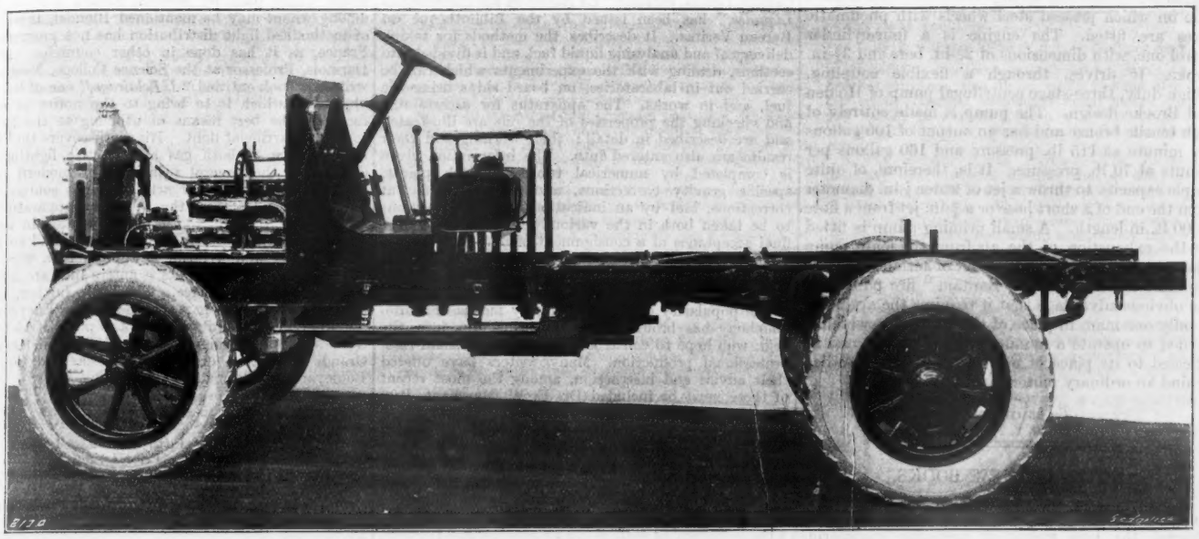


Fig. 4. 22·4-H.P. Daimler Chassis; The Daimler Company, Limited, Coventry.

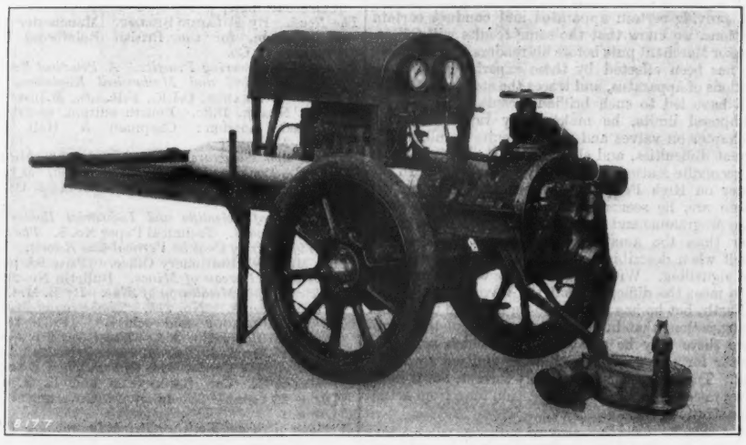


Fig. 5. Bantam Fire Pump; Tilling-Stevens Motors, Limited, Maidstone.

on "Fuel Resources and Supplies for Road Transport" and "Roadside Re-victualling" will be read by Admiral Sir Edmond J. W. Slade and Major E. G. E. Beaumont respectively, at a joint meeting of the Commercial Motor Users' Association and the London and Provincial Omnibus Owners' Association. The same organisations have arranged for papers to be read on November 28 by Mr. C. le M. Gosselin on the subject of "The Advantages and Limitations of Road Transport for Goods and Mineral Traffic" and Mr. G. W. Watson on "Multi-axle Vehicles and Combinations." Town planning also forms part of the scope of this exhibition, and many models and drawings are on view to demonstrate the schemes of a number of our large cities.

An example of a commercial motor vehicle of large capacity and of good design is illustrated in Figs. 1 to 3. This machine is a Scammell 12-ton six-wheeler, which can tip its load from the back or from either of the two sides. The manufacturers, Scammell Lorries, Limited, of Fashion-street, London, also build heavy oil tank wagons and general purpose lorries on the same principle of six-wheel support, and examples of all these machines are available for inspection at Olympia. The engine installed in these vehicles is of 50 h.p. and has four cylinders cast in pairs. The drive is taken by a spiral bevel transmission system to a counter-shaft from which the final drive to the wheels is obtained with the use of "Coventry" chains. A view of this driving axle is shown in Fig. 2, from which its sturdy construction is apparent, while the third illustration, Fig. 3, shows the substantial supporting turntable for the front end of the carrier. The machine illustrated has a body 15 ft. 6 in. long and a net capacity of 12 cub. yards, without any heaping up of the load. A special carrier has been designed for this tipping wagon, of which the side frame members are no less than 13 in. deep at the centre, where they take the thrust of the tipping rams, and the whole machine is a striking example of the way in which the six-wheeler system enables special bodies and carriers to be associated with a standard motive power unit.

The double telescopic rams are supplied with oil under pressure by a three-throw pump mounted on the power unit. This oil is conveyed through flexible metallic piping which is carried round a guard rail at the back of the car. The horns on this guard rail prevent the pipe from touching the road wheels, when in the full lock position. There are many distinctive features in this machine such as the mounting of the rams on double trunnions for their lateral movements, an arrangement which gives great stability when in the end tipping position. A special control valve is fitted which shuts off the supply of oil when the safe limit of travel is reached in the process of side tipping. It may be stated that the load may be discharged in one minute to the side and one and a-half minutes to the back.

The general purpose carrier of the same firm is so arranged that it can in a few minutes be converted from a flat platform body with chock rail, into one with hinged and removable sides, 2 ft. high, secured to steel stanchions, 4 ft. high, which serve to steady any portion of the load that extends above the top of the sides. A third modification is also possible by bolting hoops of channel section steel to the tops of the stanchions to carry longitudinal wooden rails which are used to support sheets to make a tilting van. In this condition the sides can be dropped without removing either hoops or sheeting. The oil tank wagon, which Scammell Lorries, Limited, are exhibiting, is also fitted with a drop frame carrier which accommodates a large tank in three sections, while there is a separate tank mounted over the turntable. The total capacity of all the compartments is 2,000 gallons.

The sleeve-valve engine has been applied to the driving of commercial vehicles, and an example of a chassis in which the power unit is of this type is shown in Fig. 4. This is a 22·4 h.p. model which is standardised by The Daimler Company, Limited, of Coventry. In the exhibition it is shown with various types of bodies, such as a double-deck omnibus, a char-a-banc and a tipping wagon. The nominal power of the unit, 22·4 h.p., is that of the Treasury rating and is obtained from six cylinders of 95 mm. bore and 140 mm. stroke. The lay-out of this attractive chassis, with its straight steel frame and its semi-elliptic spring suspension, is clearly shown in the illustration. A four-speed and reverse gear is provided and the transmission is effected through a fabric-lined cone clutch. A power-driven inflation pump is fitted as part of the normal equipment. The tipping wagon is provided with a steel body of 120 cub. ft. capacity, operated by a horizontal hydraulic gear with a single ram. For that service the steel wheels are provided with heavy solid tyres, singly on the front wheels and in pairs on the rear ones.

On the stand of Messrs. Tilling-Stevens Motors, Limited, of Maidstone, are shown a chassis fitted with the well-known system of petrol-electric drive and a complete example of their double-deck, London-type omnibus. In addition there is exhibited a "Bantam" fire pump, which has been designed to meet the requirements of estates and institutions

where, although the man power is limited, a really effective fire fighting machine is required. The fire pump, which is shown in Fig. 5, is built up on a frame composed of steel sections, which is supported by flat leaf springs from the tubular steel axle on which pressed steel wheels with pneumatic tyres are fitted. The engine is a four-cylinder petrol one, with dimensions of $2\frac{3}{8}$-in. bore and $3\frac{1}{4}$-in. stroke. It drives, through a flexible coupling, a high-duty, three-stage centrifugal pump of Holden and Brooke design. The pump is made entirely of high tensile bronze and has an output of 100 gallons per minute at 115 lb. pressure and 160 gallons per minute at 70 lb. pressure. It is, therefore, of quite ample capacity to throw a jet of water $\frac{7}{8}$ in. diameter from the end of a short hose or a $\frac{3}{4}$-in. jet from a hose 1,000 ft. in length. A small priming pump is fitted for the exhaustion of the air from the main pump when starting. It can be cut out of action whenever the start is made. The "Bantam" fire pump has the obvious advantage that it requires the attention of only one man, in place of the large crew which is needed to operate a manual fire engine. It can be wheeled to its place of use by two men or trailed behind an ordinary motor car.

(To be continued.)

NOTES ON NEW BOOKS.

It is some years since the opinion was expressed in our columns that the calculus of finite differences afforded the best means of preparing engineering students for the study of the differential and integral calculus. It is therefore gratifying to note that professional mathematicians are coming round to the same view. This is clearly shown in the preface to a "*Short Course on Interpolation*" which has just been published by Messrs. Blackie and Son, Limited, at 5*s*. net. This treatise has been prepared by Professor E. T. Whittaker, F.R.S., in conjunction with Mr. George Robinson, M.A., B.Sc. In the preface the remark is made that until recently the subject has been commonly neglected in the mathematical schools of British Universities, "but of late years there has been a wider acceptance of the view that the subject is easy enough to be put at the beginning of a student's course, that it forms an excellent preparation for the differential calculus, and that it cannot be left out." The text book is divided into four chapters, of which the first deals with interpolation between numbers tabulated for equal intervals of the argument, and with the representation of polynomials in a factorial form. In the next chapter interpolation between numbers "unequally spaced" is dealt with, the method based on divided differences being given as well as the more familiar formula of Lagrange. The third chapter on central difference formulas is specially adapted to meet needs of professional computers. For most engineers, the interest of the calculus is limited to the case of advancing differences only. In the concluding chapter of the volume, it is shown that tables of finite differences may be used to calculate differential coefficients. Theoretically this method is, of course, a perfectly legitimate one, but it requires to be used with intelligence. We have known engineers, for example, to apply the method to determine, not merely the first, but also the second differentials of observational data. Such data may, however, be taken as really illustrating the fact, frequently insisted on by the pure mathematician, that most functions have no derivatives. Actual observations, in fact, never do lie accurately on a smooth curve, but merely about it, and it is this curve that has a differential at every point, whilst there is none at the point represented by an actual observation.

Among recent publications of the Sammlung Goeschen, of Berlin (an association of scientific publishers) we notice "*Die Dampfturbinen*," Part II, "*Berechnung der Dampfturbinen und Konstruktion der Einzelteile*," by Professor C. Zietemann, of Chemnitz. Like all these publications, it is only a small book; but the 138 pages, illustrated by 142 text figures, deal with the problems of the calculation and construction of steam turbines and their parts in a decidedly instructive, though necessarily brief way. The names of designers or firms added to the diagrams facilitate inquiry. We may mention two other new books of the same publishers, Professor H. Wegele's "*Linienführung der Eisenbahnen*" (Planning of Railways), and "*Heizung und Lüftung*," Part II, "*Ausführung der Anlagen*" (Heating and Ventilation), by Johannes Körting. These volumes are published at 1*s*. each.

The use of liquid fuel both in steam boilers and in internal-combustion engines, has made great progress of late years and is being further developed. One of the difficulties which purchasers of this fuel have frequently to contend with is the irregularity in the composition of different consignments. In order to meet this difficulty, a book in the French language, by Mr. Camille Denier, entitled "*La Reception des Combustibles Liquides*," has been issued by the Bibliothèque du Bureau Veritas. It describes the methods for taking delivery of and analysing liquid fuel, and is divided into sections, dealing with the experiments which can be carried out in laboratories, on board ships using the fuel, and in works. The apparatus for ascertaining and checking the properties of the oils are illustrated and are described in detail; their working and their results are also entered into. The information given is completed by numerical tables of flash points, specific gravity corrections, and volume coefficient corrections, and by an indication of the precautions to be taken both in the various tests and before the final acceptance of a consignment of oil. The book is published at the price of 12 francs by Mr. E. Chiron, 40, Rue de Seine, Paris.

The popularity of broadcasting by means of radio-telephony has brought many experimenters into the field, who hope to construct apparatus that shall rival professional production. Many writers have offered their advice and instruction, among the most recent of these must be included Dr. E. W. Marchant, Professor of Electrical Engineering in the University of Liverpool. In a handy little book, "*Radio Telegraphy and Telephony*" (Hodder and Stoughton; 6*s*. net), Professor Marchant revises the materials of his lectures delivered under the auspices of the Extension Board of the University. His object is limited to explaining to those who have some slight knowledge of electricity, what is happening both at the transmitter and receiver, when a radio message is heard. This task in its completeness passes the wit of man. In the first sentence, we are brought up against the "all-pervading ether," a very ingenious device that conceals many difficulties. If we provide certain apparatus and conduct certain operations, we know that the same results will follow. Professor Marchant puts before his readers very cogently what has been effected by these experiments and by variations of apparatus, and traces the steps historically which have led to such brilliant results. Within his self-imposed limits, he makes very rapid headway. His chapter on valves and valve circuits is full, shirks no great difficulties, and should give a clear notion of such recondite matters as heterodyne reception. In the chapter on High Frequency Alternators, and on the Poulsen arc, he seems to be getting away from his simple programme and to be addressing the professional rather than the amateur element, but he recovers himself when describing directional and long-distance radio signalling. With long-distance transmission he has to meet the difficulty that the waves travel round the Earth, but he has nothing more novel to offer than the suggestion, that in the upper regions of the atmosphere there may be a layer of air, which acts as a reflector for the waves which were emitted from the aerial. The hypothesis is probably correct, but it holds its own rather from lack of competition than from actual demonstration.

A few years after Mr. H. Brearley had brought out his book on "The Heat Treatment of Tool Steels" in 1911, an authorised German version of this well-known book appeared under the title "Brearley-Schäfer, Die Werkzeugstähle und Ihre Wärmebehandlung." The change in its title indicated that Dr. Ing. Rudolf Schäfer's version was not a translation, and the third edition of this German work, which appeared last year, indeed differed considerably from the English original. Dr. Schäfer's new book, "*Die Konstruktionstähle und ihre Wärmebehandlung*" (Berlin: Julius Springer; price 15*s*. 11*d*.), may be considered a sequel to the former work. Books on structural steels and on tool steels appeal to different classes of readers; but the two subjects have much in common, and references to Brearley-Schäfer are frequent in the new publication. Dr. Schäfer has to open with a chapter on the nomenclature of iron and steel. That nomenclature remains unsettled in most languages and countries, and Dr. Schäfer might, in his introduction, have spoken a little more decisively and might, so far as possible, have given definitions rather than remarks on terms, particularly as he later on admits that some firms, even large firms, still leave too much latitude to their buyers, though aware of their want of technical training. But, like Mr. Brearley, he does not theorise much; he prefers to give advice as to what the materials will do provided they be properly prepared and treated subsequently. Metallurgists can supply us with kinds of iron and steel varying as regards hardness, toughness, strength, malleability, &c., to an astounding degree, unapproached by any other material. But chemical analyses, microphotographs and test certificates of material samples do not give us any guarantee as to the behaviour of the individual piece. We must know the individual history. That is one of the points emphasised in the 360 pages of the volume before us, which is well illustrated and well arranged generally.

Notwithstanding the research work carried out for many years past by several French learned men, among whom may be mentioned Blondel, the science of methodical light distribution has not progressed in France, as it has done in other countries. Mr. E. Darmois, Professor at the Science College, Nancy, has written a book entitled "*L'Eclairage*," one of the main objects of which is to bring to the notice of manufacturers the best means of utilising to the full the sources of artificial light. His work covers the theory and practice of both gas and electric lighting, and deals with the general principles of modern photometry, the properties of artificial light sources, their characteristic features, the accessory apparatus used to distribute the light to the best advantage in apartments, shops and public thoroughfares, and so forth. The book is well written, it appeals to a very wide circle, and if the arguments it enters into are followed will render a real service. The book, further, is well indexed. It forms part of the series Encyclopédie Léauté, and can be obtained at the price of 15 francs, from Messrs. Gauthier-Villars and Co., 55, Quai des Grands Augustins, or Messrs. Masson and Co., 120, Boulevard, St. Germain, Paris.

BOOKS RECEIVED.

The Cycling Manual. Fifth edition. London: The Temple Press, Limited. [Price 1*s*. net.]

Cost Control for Foundries. By Frank Everett and Johnson Heywood. Edited by Wm. R. Basset. First edition. London: McGraw-Hill Publishing Co., Limited. [Price 15*s*. net.]

Blasting with High Explosives. By W. Gerard Boulton. London: Sir Isaac Pitman & Sons, Limited. [Price 5*s*. net.]

Alternating Current Bridge Methods. By B. Hague, M.Sc. London: Sir Isaac Pitman & Sons, Limited. [Price 15*s*. net.]

The Road. By Hilaire Belloc. Manchester: Charles W. Hobson, for the British Reinforced Concrete Engineering Co.

Electrical Engineering Practice. A Practical Treatise for Electrical, Civil and Mechanical Engineers, Vol. I. By J. W. Meares, C.I.E., F.R.A.S., M.Inst.C.E. and R. E. Neale, B.Sc. Fourth edition, re-written and enlarged. London: Chapman & Hall, Limited. [Price 25*s*. net.]

Strength and Structure of Steel and other Metals. By W. E. Dalby, F.R.S., M.A., B.Sc., M.Inst.C.E., M.I.Mech.E. London: Edward Arnold & Co. [Price 18*s*. net.]

Department of Scientific and Industrial Research, Fuel Research Board. Technical Paper No. 8. *The Steaming of Wigan Arley Coal in Vertical Gas Retorts.* London: His Majesty's Stationery Office. [Price 9*d*. post free.]

United States Bureau of Mines. Bulletin No. 208. *The Electrothermic Metallurgy of Zinc.* By B. M. O'Harra. [Price 15 cents.] No. 215. *Timbering of Mines.* By E. A. Holbrook and others. [Price 25 cents.] Technical Paper No. 304. *Water Gas Tar Emulsions.* By W. W. Odell. [Price 10 cents.] No. 312. *Leaching Non-Sulphide Copper Ores with Sulphur Dioxide.* By Charles E. Van Barneveld and E. S. Leaver. [Price 20 cents.] Washington: Government Printing Office.

Working of Steam Boilers; Being Instructions Respecting the Working, Treatment, and Attendance of Steam Boilers. By Edward G. Hiller, B.Sc., M.Inst.C.E., M.I.Mech.E. Sixth edition, revised and enlarged. Manchester: The National Boiler and General Insurance Company, Limited. [Price 3*s*. 6*d*. net.]

Aeronautical Research Committee. Reports and Memoranda, No. 802. *Experiments on Model of a Rigid Airship of New Design.* By R. Jones, M.A., and others. [Price 1*s*. 3*d*. net.] No. 806. *On the Theory of Tapered Aerofoils.* By A. Fage, A.R.C.Sc. [Price 1*s*. net.] No. 814. *Experiments on Rigid Airship R* 32. Part IV. *Note on Measurements of Airscrew Thrust.* By R. A. Frazer and H. Bateman. [Price 6*d*. net.] No. 839. *The Constitution and Age-Hardening of Alloys of Aluminium with Copper, Magnesium and Silicon, in the Solid State.* By Marie L. V. Gayler, M.Sc. [Price 1*s*. 3*d*. net.] No. 843. *The Constitution of Some Alloys of Aluminium with Copper and Nickel.* By Kathleen E. Bingham, M.Sc., and John L. Haughton, D.Sc. [Price 2*s*. net.] No. 846. *The Lateral Stability of S.E.* 5*a in Gliding Flight.* By E. F. Relf. [Price 9*d*. net.] No. 847. *The No.* 2 7-*Ft. Wind Channel at the Royal Aircraft Establishment.* By the Wind Channel Staff. [Price 4*d*. net.] No. 848. *Rolling and Yawing Moments due to Roll of Model Aero Wings, with Standard and Interplane Ailerons and Rudder Moments for Standard and Special Large Rudders.* By F. B. Bradfield and O. E. Simmonds. [Price 1*s*. net.] No. 849. *The Effect upon the Control of an Aeroplane on Carrying Load Distributed along the Planes.* By the Aerodynamics Staff of the R.A.E. [Price 3*d*. net.] No. 851. *The Comparison of the Manœuvrability of Aeroplanes, by the Use of a Cinematograph Camera.* By H. A. Francis. [Price 1*s*. net.] No. 853. *Note on Temperature Measurements.* By F. M. Green, M.Inst.C.E., and W. S. Renwick. [Price 1*d*. net.] No. 870. *Full Scale Determination of the Characteristics of a Variable Pitch Airscrew.* By F. W. Meredith. [Price 6*d*. net.] [London: His Majesty's Stationery Office.

THE USE OF MERCURY IN BINARY FLUID TURBINES.

*The Possibilities of Mercury as a Working Substance for Binary Fluid Turbines.**

By WILLIAM J. KEARTON, M.Eng., of the Walker Engineering Laboratories, University of Liverpool.

1. *Introduction.*—It is hardly necessary to emphasise at the present moment, that conservation of our national fuel resources is a matter of the greatest importance. Many power plants of small and moderate size are operating very economically, and it is only when new plants are being put down or when old machinery is being replaced by new, that any considerable improvement can be effected. It does not follow that a high thermal efficiency is synonymous with high commercial efficiency. A high thermal efficiency is necessarily associated with the use of high temperatures, and it is well known that the advantages due to increased thermal efficiency might be more than outweighed by the interest on the increase of capital necessary to effect the thermal improvements, the increased rate of depreciation of the plant, and possibly by the reduced reliability of the plant.

Considerable improvements in the generation of electric power have been made in the past few years. Such improvements relate to the use of high steam pressures, large-powered high-speed turbines, efficient air-extraction apparatus and improved methods of feed-heating. As a result, overall thermal efficiencies (coal to switchboard) of the order of 20 per cent. have been recorded, and in one instance a thermal efficiency of about 24 per cent. is predicted.

The object of this paper is first to discuss very briefly the methods of improving the efficiency of large steam turbines, and to outline the possibilities of the binary fluid turbine with mercury and water as the working substances.

2. *The Efficiency of Steam Turbines.*—In discussing the relative efficiencies of the steam turbine and the mercury vapour turbine, the Rankine cycle, with complete expansion, will be used throughout as the basis of comparison. This is considered to be quite valid, since there is no reason to believe that the efficiency ratio of the mercury-vapour turbine will be any less than that of the steam turbine.

The temperature-entropy diagram for the Rankine cycle (steam turbine) is shown in Fig. 1. T_1 is the absolute temperature corresponding to the initial steam pressure, T_3 is the absolute temperature to which the steam is superheated, T_2 is the absolute temperature corresponding to the turbine exhaust pressure.

For steam initially dry and saturated, the work done per pound of steam is represented by the area *a b c d*, the heat supplied by the area *k a b c m*, and hence, the thermal efficiency of the ideal turbine is equal to the ratio

$$\frac{\text{Area } a\,b\,c\,d}{\text{Area } k\,a\,b\,c\,m}$$

If the steam be initially superheated to T_3, it is clear that the additional work done is given by the area *d c e f*, and the additional heat to be supplied, by the area *m c e n*. The thermal efficiency of the ideal turbine is then equal to the ratio

$$\frac{\text{Area } a\,b\,c\,e\,f}{\text{Area } k\,a\,b\,c\,e\,n}$$

Owing to the increased range of temperature for the superheat part of the cycle, the efficiency is higher, but the increase is relatively small, owing to the small amount of heat absorbed by the working substance during superheating.

Suppose now, that the initial steam pressure is increased, such that the saturation temperature is T_1', and further, suppose that the maximum steam temperature remains unaltered at T_3. An inspection of Fig. 1 (which is drawn to scale) shows that there is an increase in the amount of work done and a decrease in the amount of heat supplied, and as a consequence, the efficiency may be better improved by the use of high steam pressures than high superheats. This is further illustrated by Fig. 2,* in which the thermal efficiency of the ideal turbine is set down against the total steam temperature. For example, suppose the total steam temperature to be 600 deg. F. Steam at 200 lb. pressure absolute would be superheated 218 deg. F. and the thermal efficiency would be 32·85 per cent. With a steam pressure of 500 lb. per square inch absolute, the superheat would now be only 131·4 deg. F., but the efficiency would be 36·8 per cent.; an increase of 12 per cent. on the previous figure.

Unfortunately apart from other drawbacks, high steam pressures tend to reduce the efficiency ratio of the steam turbine for the following reasons:—

(*a*) With the use of higher steam pressures, the steam density will be greater, and consequently, the losses due to windage and gland leakage in impulse turbines and due to tip clearance leakage in reaction turbines will be considerably increased.

(*b*) For a given total steam temperature, an increase in pressure involves a reduction in superheat and during its expansion through the turbine, the steam loses its superheat sooner, with a considerably lower efficiency in the low-pressure stages.

(*c*) For a given standard turbine frame, an increase in steam pressure would result in an increased heat-drop and a less favourable value of the ratio of blade speed to steam speed.

On the other hand, with higher steam pressures, the amount of condenser cooling surface required is somewhat reduced, the reduction amounting to from 10 to 12 per cent. for an increase of steam pressure from 200 lb. to 590 lb. per square inch. The advantages accruing to the use of high-pressure steam are too great to be ignored, and in recent years, experiments in this direction have been carried out in Germany with steam engines and boilers working at 900 lb. per square inch and a total temperature of 842 deg. F. These experiments are so important that a brief reference will be made to them.

A number of experimental engines have been built, and the aim throughout has been to improve the thermodynamic efficiency of the cylinders. The high-pressure cylinder was quite satisfactory and gave an efficiency of over 90 per cent. (indicated) with an initial steam pressure of 900 lb., and a back pressure of 45 lb. per square inch. The low pressure cylinder, however, gave an efficiency of only 50 per cent. or less. The most effective way of increasing the thermodynamic efficiency was found to be re-superheating the steam.

On the sixth experimental engine of 100 h.p., the efficiency of the low-pressure cylinder has, by re-superheating, been increased to 80 per cent. to 85 per cent. As a result of tests, it is estimated that with a large engine and suitable improvements in design, a heat consumption of 8,000 B.Th.U. per indicated horse-power-hour could be obtained, giving an indicated thermal efficiency of nearly 32 per cent.

The application of the principle of re-superheating to large steam turbines is by no means new. Experiments were carried out in this country eleven or twelve years ago. Its efficacy when applied to the turbine, however, is much less than when applied to the piston engine; because in large-powered turbines, the necessary pipe connections become costly and unwieldy, and, except in power stations where the feed water is heated in multi-stage heaters by steam tapped from the main turbine and where re-superheating would effect a saving of part of the heat in the flue gases which would otherwise be wasted, it is not likely to have a wide application. A small improvement in the overall economy of a steam-turbine plant may be effected by tapping off steam from the turbine at one or more points and utilising the latent heat of such steam for heating the feed water. It is not usually practicable to install more than one or two heaters. The reduction in heat-consumption of the whole plant amounts to about 4 per cent. to 5 per cent. with a single heater and about 6 per cent. to 7 per cent. with two-stage heating.

To summarise the present position of the single-fluid steam turbine, if a total temperature of 750 deg. F. be assumed, the efficiency of the ideal turbine operating between pressure limits of 600 lb. per square inch absolute and 0·5 lb. per square inch absolute would be 38·2 per cent. Assuming a turbine efficiency of 80 per cent, a generator efficiency of 95 per cent., and a boiler efficiency of 80 per cent., the overall thermal efficiency of the plant would be

$$38{\cdot}2 \times 0{\cdot}8 \times 0{\cdot}95 \times 0{\cdot}8 = 23{\cdot}2 \text{ per cent.}$$

By utilising low-temperature turbine steam for feed-heating purposes, this figure would become about 24·4 per cent. Thermal efficiencies much higher than this can hardly be expected, even with very considerable increases in the total temperature, for the reasons already given.

3. *The Binary Fluid Turbine.*—The fundamental difficulty with steam is the fact that at what may, in future, be regarded as moderate temperatures, the vapour pressure is too high. The ideal working substance for our high-temperature low-pressure turbine would have a high boiling-point and would exert fairly high vapour pressures at temperatures round about that of our circulating water. In other words, its temperature-pressure curve would be of the form indicated by the dotted line in Fig. 3, crossing the steam line as shown. There is no such fluid in existence.

There are fluids which have a high boiling-point, but at normal condenser temperatures their vapour pressure is extremely low. This point will be appreciated if reference be made to Table 1, below, in which a few vapour pressures of mercury and steam are set down for the same temperatures.

The greatest efficiency that can be realised in any heat engine is measured by the ratio

$$\frac{T_1 - T_2}{T_1}$$

which is the efficiency of the Carnot cycle for given maximum and minimum temperatures T_1 and T_2 respectively. Considering the expansion of dry saturated vapour with reference to Fig. 1, annexed, it is apparent that the Carnot cycle (and hence the highest possible thermal efficiency for any given temperature limits) will be more nearly realised, the nearer the liquid line *a b* approaches the constant entropy line *b g*. In other words, the efficiency of the Rankine cycle for the liquid and its vapour will be a greater or less fraction of the highest possible efficiency according as the ratio $\frac{b\,c}{a\,g}$ is greater or less.

Now *b c* is equal to $\frac{L}{T}$, where L is the latent heat of vaporisation at T and *a g* is equal to

$$\int_{T_2}^{T_1} \frac{C \cdot d\,T}{T} = \int_{T_2}^{T_1} f(T) \cdot \frac{d\,T}{T}.$$

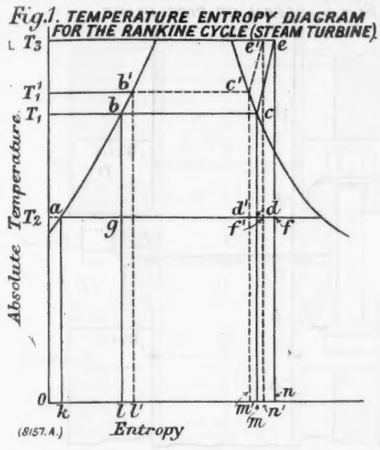
C being the specific heat of the liquid, which usually varies slightly, being a function of T. If C may be assumed constant, then

$$a\,g = C.\log_e \frac{T_1}{T_2}.$$

TABLE 1.—*Vapour Pressures of Mercury and Steam.*

Temp.	Vapour Pressure. Mercury.	Vapour Pressure. Steam.	Ratio: Vap. Press. of Steam / Vap. Press. of Hg.
deg. F.	lb. per sq. in. abs.	lb. per sq. in. abs.	
32	0·0000031219	0·0886	28,350
100	0·000093994	0·946	10,060
200	0·0037296	11·52	3,090
300	0·053513	67·0	1,250
400	0·39841	247·1	620
500	1·863	679·0	364
600	6·625	1,540·0	232
700	18·886	—	—
706·1	20·0	3,200·0	160
800	45·343	—	—
900	95·340	—	—
1,000	180·460	—	—

Hence the value of the ratio $\frac{L}{C}$ for the ideal fluid should



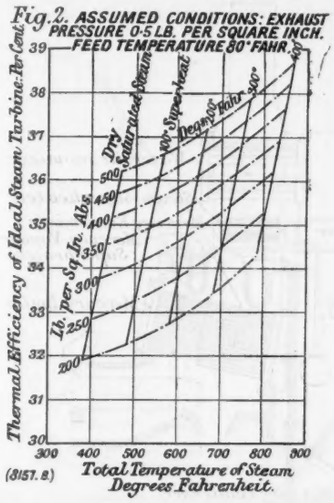


Fig.2. ASSUMED CONDITIONS: EXHAUST PRESSURE 0·5 LB. PER SQUARE INCH. FEED TEMPERATURE 80° FAHR.
Thermal Efficiency of Ideal Steam Turbine. Per Cent.
Dry Saturated Steam
100° Super-Heat
Degs. Fahr. 590°
Lb. per Sq. In. Abs.
Total Temperature of Steam Degrees Fahrenheit.
(8157.B.)

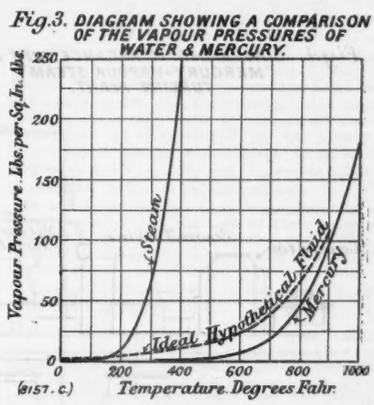


Fig.3. DIAGRAM SHOWING A COMPARISON OF THE VAPOUR PRESSURES OF WATER & MERCURY.
Vapour Pressure. Lbs. per Sq. In. Abs.
Steam
Ideal Hypothetical Fluid
Mercury
Temperature. Degrees Fahr.
(8157.C.)

* Paper read before the Institution of Mechanical Engineers, on Friday, November 16, 1923.

* This diagram is based upon the steam tables of Professor Callendar.

be as great as possible. A direct comparison of the values of $\frac{L}{C}$ for mercury and steam is made in Table II.

Whilst there is no appreciable change in the value of this ratio for mercury, there is a considerable variation for steam, the probable reason being, that within the range of temperature considered, steam is much nearer its critical point than mercury.

TABLE II.—*Values of* $\frac{L}{C}$ *for Mercury and Steam.*

Temp.	Mercury.			Steam.		
	L.	C.	$\frac{L}{C}$	L.	C.	$\frac{L}{C}$
deg. F.						
32	132·97	0·0335	3,970	1,073·4	1·009	1,064
100	132·31	0·0332	3,990	1,035·6	0·9967	1,040
200	131·34	0·0329	4,000	977·8	1·0039	973
300	130·37	0·0328	3,980	909·5	1·029	884
400	129·41	0·0329	3,940	827·2	1·064	777
500	128·44	0·0332	3,870	727·0	1·112	653
600	127·47	0·0335	3,810	585·0	1·172	500
700	126·58	0·0338	3,750	—	—	—
800	125·94	0·0341	3,690	—	—	—
900	125·29	0·0345	3,640	—	—	—
1,000	124·65	0·0347	3,600	—	—	—

in the United States of America by the General Electric Company to the designs of Mr. Emmet, and further that a second turbine has just recently been put into operation. No published information on the subject has, so far as the author is aware, appeared in this country.

A diagrammatic arrangement of a complete "mercury-vapour steam" turbine plant is shown in Fig. 4. Mercury

TABLE III.—*A Comparison of the Thermal Efficiencies of Mercury-Vapour and Steam Turbines operating between approximately the same Limits of Temperature.*

——	Mercury.	Steam.
Initial pressure, lb. per sq. in.	1·5	600·0
Initial temperature, deg. F.	484·6	486·4
Final pressure, lb. per sq. in.	0·001	4·737
Initial quality	Dry and saturated.	
Initial total energy, B.Th.U.	143·518	1,211·0
Final total energy, B.Th.U.	97·300	885·4
Heat drop, B.Th.U.	46·218	325·6
Net heat supplied, B.Th.U.	139·258	1,083·14
Thermal efficiency, per cent.	33·24	30·07
Percentage gain	10·54	—

Fig.4. DIAGRAMMATIC ARRANGEMENT OF "MERCURY-VAPOUR STEAM" TURBINE PLANT.

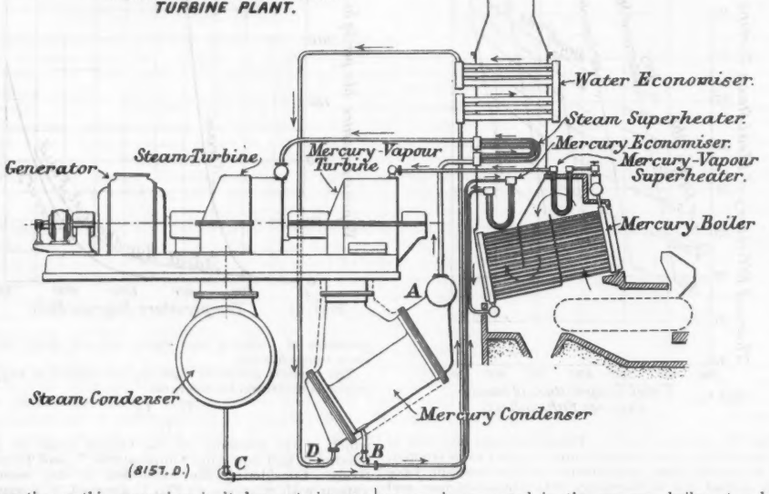
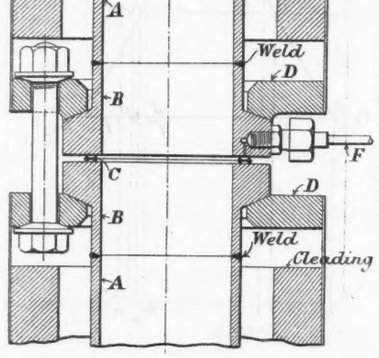
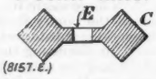


Fig.5. DETAIL OF PIPE-JOINT.



ENLARGED SECTION OF JOINT RING.



Holes are drilled through the ring as shown, to enable vapour to pass from one side to the other.

Interesting as this comparison is, it does not give one any precise idea as to the influence of the ratio $\frac{L}{C}$ on the efficiency. For this purpose, a comparison of the efficiency of a mercury-vapour turbine and of a steam turbine, working between approximately the same temperature limits with initially dry vapour, is set out in Table III. The improvement in the thermal efficiency of the cycle, namely, 10·54 per cent., is not inconsiderable and enhances the importance of mercury as a working substance for binary fluid turbines.

The desiderata of the ideal fluid for a single fluid turbine are therefore:—

(*a*) A high boiling-point.

(*b*) A relatively high pressure at the temperature of circulating water.

(*c*) A high value of the ratio $\frac{L}{C}$.

In view of the difficulty of securing sufficient nozzle area in the last stage of large turbines, a further desideratum would be a large mass-rate of flow per unit nozzle area. This point will be dealt with later under "the flow of vapour through nozzles."

It has already been stated that no fluid exists which fulfils all these conditions, and consequently we are driven to the use of two fluids; one, with a high boiling-point, to be used in a high temperature turbine, the other, with a low boiling-point, to be used in the low-temperature turbine. The binary fluid principle is not new, having been proposed about 1850 by Du Tremblay. Its earlier applications lay in the use of a volatile liquid such as ether, sulphur dioxide, or carbon bisulphide to operate in conjunction with steam. Owing to the inability of the reciprocating steam engine to utilise high vacua efficiently, there was a limited field of application for the binary fluid engine using steam as the high temperature fluid and a more volatile substance as the low-temperature fluid. The steam turbine, however, is admirably suited to the highest vacuum possible; the limit being set, in almost every instance, by the temperature of the circulating water available. Thus the steam now becomes the low-temperature fluid, and mercury or other suitable substance the high-temperature fluid. Other substances include aniline and the heavy oils, but these will not be considered. It is stated that an experimental mercury-vapour turbine has been built

vapour is generated in the mercury boiler at a high temperature and a moderate pressure, and may be superheated or delivered direct to the turbine in a more or less dry condition. Owing to the great density of the liquid, drying of the wet vapour should be a relatively easy matter. After expansion in the turbine, the vapour enters the condenser in which the latent heat of the mercury vapour generates steam, which collects in a collector A. The liquid mercury is then pumped out by an extraction pump B and passed through the mercury economiser into the boiler. Due to the very high cost of mercury, the total weight of mercury in the system must be a minimum. This depends upon the volumetric capacity of the economiser and boiler in the first place, and in the second place upon the rapidity of circulation. It is clear that the ratio

$$\frac{\text{Rate of heat transmission}}{\text{Mass of mercury in boiler}}$$

will be a maximum when the diameter of the tubes is least. On account of the purity of mercury, trouble due to incrustation would hardly be anticipated, and there seems to be no reason why the major portion of the heating surface should not be provided by a large number of tubes of small diameter.

Owing to the poisonous nature of mercury vapour and also to its high cost, leakage must be entirely eliminated. It is stated that in the first experimental turbine constructed in America, the boiler pipe connections were welded. Whilst this is a sure way of preventing leakage, it has obviously undesirable features; and for certain joints which might require to be broken now and again, the pipe-joint shown in Fig. 5 is suggested. Ends B are welded to the pipes A, as shown. A double diamond-section ring C of nickel is nipped between the flanges B and embeds itself into the flanges. Each flange is provided with a spherical seat and a loose ring D, which must be slipped on to the pipe before welding. With this arrangement, however unequally the bolts may be tightened up, the pressure between the flanges and the ring C would be equally distributed all round. A connection between the space E and the condenser would be made by the pipe F so that any vapour leaking past the first ring would flow into the condenser. It is considered that the prevention of leakage at the turbine glands would present no insuperable difficulties and could be overcome by the use of a suitable labyrinth and impeller type of gland.

In describing the steam cycle, a start may be made at the extraction pump C of the plant, Fig. 4, which, in conjunction with the feed pump, delivers the feed water into the economiser where a certain amount of sensible heat is taken up by the water. From thence it enters the mercury condenser at D, passes through an inclined bank of tubes in which it is evaporated, and collects in the collector A. It then passes successively through the superheater, turbine and condenser in the usual manner.

4. *The Properties of Mercury.*—A considerable amount of experimental work has been done by chemists and physicists on the properties of mercury, but, unfortunately, the whole of the data necessary for a complete study of the problem are not at hand, and a large amount of research work, particularly in connection with the determination of latent heats at high temperatures, remains to be done. A brief discussion of the various properties of mercury will now be given.

5. *Vapour-pressure Determinations.*—A large number of consistent determinations of the vapour pressure of mercury over a very wide range of temperature (32 deg. to 1,616 deg. F.) have been made by various investigators, notable amongst whom are Knudsen and Morley, who independently made experiments at very low pressures, Hertz, Ramsay and Young, and Smith and Menzies. The high-temperature research was carried out by Cailletet, Colardeau and Rivière. Various formulæ have been proposed from time to time to express the relationship between pressure and temperature of saturated vapours. For steam, Rankine proposed the formula—

$$\log p = a - \frac{\beta}{T} - \frac{\gamma}{T^2},$$

where p is the vapour pressure, T is the absolute temperature, and a, β, γ are empirical constants. Hertz proposed, in 1882, a formula of the type—

$$\log_{10} p = a - \frac{\beta}{T} - \gamma \log_{10} T.$$

This has been applied in the case of mercury by Knudsen* for very low pressures. Knudsen's equation is—

$$\log_{10} p = 10{\cdot}5724 - \frac{3342{\cdot}26}{T} - 0{\cdot}847 \log_{10} T \quad (1)$$

where p is the pressure in mm. of mercury and T is the absolute temperature Centigrade. Knudsen's formula is only accurate at low pressures. Up to 480 deg. F., a formula which expresses the experimental results more accurately then Knudsen's is proposed by Laby (Phil. Mag., November, 1908)—

$$\log_{10} p = 15{\cdot}24431 - \frac{3623{\cdot}932}{T} - 2{\cdot}367233 \log_{10} T \quad (2)$$

In the computation of the Tables 9–11 (not reproduced, Ed. E.) this formula has been used for all temperatures below 480 deg. F. If p be in lb. per square inch absolute and T be the absolute temperature in degrees Fahrenheit, then Laby's formula may be written—

$$\log_{10} p = 14{\cdot}13499 - \frac{6523{\cdot}076}{T} - 2{\cdot}367233 \log_{10} T \quad (3)$$

Another formula of the above type has been applied by Smith and Menzies.† It is exceedingly accurate over the range from 480 deg. to 815 deg. F., the average temperature deviation being less than 0·1 deg. F. Expressed

* Ann. der Physik., 1909, vol. xxix, page 179.

† Journal, American Chemical Society, 1910, vol. xxxii, page 1,434.

in pounds, inch, Fahrenheit unit, Smith and Menzies' formula becomes—

$$\log_{10} p = 8{\cdot}3601791 - \frac{5897{\cdot}88}{T} - 0{\cdot}6519904 \log_{10} T \quad (4)$$

This has been used in the construction of the Tables for all temperatures higher than 480 deg. F.

6. *Specific Heat of the Liquid.*—In the "Physikalische Tabellen," of Landolt and Börnstein, a large number of experimental values of the specific heat of liquid mercury are given. Some of these are represented graphically in Fig. 6, which shows the results of researches by Winkelmann, Naccari and Milthaler. At the lower temperatures there is fair agreement, but at the higher temperatures there is a considerable discrepancy. On the same diagram is shown a number of determinations by Barnes, taken from a paper by J. E. Mills on "Specific Heats of the Elements and some Energy Changes."* In spite of their apparent divergence from the results of the investigators mentioned above, the author has considered that Barnes' results are probably more accurate than any of the others, for reasons which will now be explained.

Following the method used by Professor Callendar in calculating his Steam Tables, the author has postulated that the heat required to raise the temperature of liquid mercury may be comprised of two amounts :—

(1) That required to raise the temperature of the mercury with a true constant specific heat, that is, $K(t - 32)$.

(2) That required to evaporate the "dissolved mercury vapour." It is assumed that when mercury and its vapour are in equilibrium at any temperature, a volume of the vapour equal to the volume of the liquid is contained within the liquid

Let v_l = volume of liquid mercury in cu. ft. per lb.
v_m = volume of mercury vapour in cu. ft. per lb.
L = latent heat of vaporisation.

Then the sensible heat—

$$h = K(t - 32) + \frac{L \cdot v_l}{v_m - v_l} - \frac{L_{32} \cdot v_{l_{32}}}{v_{m_{32}} - v_{l_{32}}} \quad . \quad (5)$$

By Clapeyron's Equation we have—

$$(v_m - v_l) \cdot \delta P = \frac{J L}{T} \cdot \delta T.$$

Then

$$\frac{L}{v_m - v_l} = \frac{dP \cdot T}{dT \quad J}.$$

But

$$\log_e p = a - \frac{\beta}{T} - \gamma \log_e T,$$

$$\therefore \frac{1}{P} \cdot \frac{dP}{dT} = \frac{\beta}{T^2} - \frac{\gamma}{T},$$

$$\therefore \frac{L}{v_m - v_l} = \frac{P}{J}\left(\frac{\beta}{T} - \gamma\right).$$

Then

$$h = K(t - 32) + \frac{144\, p \cdot v_l}{J}\left(\frac{\beta}{T} - \gamma\right) - k. \quad (6)$$

where

$$k = \frac{144\, p_{32} \cdot v_{l_{32}}}{J}\left(\frac{\beta}{491{\cdot}6} - \gamma\right).$$

Note :—

p is used to represent pressures in lbs. per sq. in.
P " " " lbs. per sq. ft.
v " " volumes in cu. ft.

Up to 480 deg. F., $\beta = 2{\cdot}302586 \times 6523{\cdot}076 = 15{,}019{\cdot}95$.
" " $\gamma = 2{\cdot}367233$.
Above 480 deg. F., $\beta = 2{\cdot}302586 \times 5897{\cdot}88 = 13{,}580{\cdot}37$.
" " $\gamma = 0{\cdot}6519904$.

The value of the constant k is $1{\cdot}917365 \times 10^{-8}$, a quantity so small as to be negligible. The value of the other constant K may be determined if, for some temperature sufficiently far removed from 32 deg. F., the value of the sensible heat is known fairly accurately. Between 32 deg. F. and 200 deg. F. there is a reasonably good agreement between all the experimental values. Hence, in calculating the value of K, the sensible heat at 200 deg. F. computed from Barnes' curve was used with the result :—K = 0·0331493.

$$\therefore h = 0{\cdot}0331493(t - 32) + \frac{144\, p \cdot v_l}{J}\left(\frac{\beta}{T} - \gamma\right) \quad (7)$$

Values of h at various temperatures have been calculated by means of this formula for the purpose of comparison with those obtained from Barnes' result, and with those calculated from a formula based on the experiments of Winkelmann, Naccari and Milthaler. These values are given in Table V.

The values of the sensible heat given in the Tables at the end of the Paper are computed by a "step-by-step" process from the experiments of Barnes. The available data is given in Table IV.

A law was assumed for the specific heat :—

$$C = a + bt + ct^2 + dt^3,$$

and taking the values at 32 deg., 212 deg., 392 deg. and 572 deg. F. to determine the constants a, b, c and d, the equation may be written :—

$$C = 0{\cdot}03369359 - (6{\cdot}472055 \times 10^{-6})\,t + (1{\cdot}405694 \times 10^{-8})t^2 - (6{\cdot}57293 \times 10^{-12})\,t^3 \quad . \quad . \quad . \quad . \quad (8)$$

This equation has been used for temperatures above the limit of the experimental data, that is, 572 deg. F. Consequently, values of the sensible heat above that temperature may be somewhat in error.

Returning to the curves 1, 2, 3 and 4 of Fig. 6, above, these are represented fairly well by the "average" equation :—

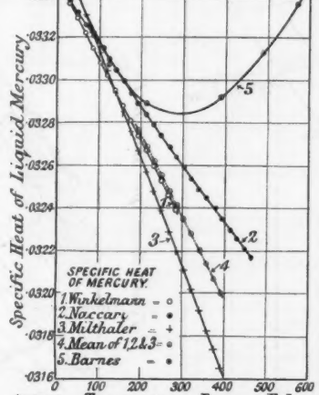
$$C = 0{\cdot}03351 - 0{\cdot}000003852t \quad . \quad . \quad . \quad (9)$$

Using these values and extrapolating to 700 deg. F., the sensible heat has been calculated for various temperatures and set down in Table V. Whilst the difference between the values in columns A and B nowhere exceeds 0·6 per cent., the difference between B and C at 700 deg. F. amounts to 3·14 per cent. Although no strictly accurate conclusion can be arrived at as a result of this investigation, it may be concluded that if the aforementioned assumption (that a certain volume of liquid mercury contains an equal volume of mercury vapour in "solution") is correct, then the specific heat determinations of Barnes are more reliable than those of the other investigators.

TABLE IV.—*Specific Heat C of Liquid Mercury (Barnes).*

Temperature. Deg. F.	Barnes' Experimental Value.	Value of C computed by Mills.
32	0·03350	0·03377
122	0·03307	0·03373
212	0·03289	0·03370
392	0·03292	0·03368
572	0·03336	0·03370

Fig. 6. EXPERIMENTAL VALUES OF THE SPECIFIC HEAT OF LIQUID MERCURY.



(8157.F.)

TABLE V.—*Comparison of Sensible Heats Computed by Various Formulæ.*

Formula A. $h = 0{\cdot}0331493(t - 32) + \frac{144\, pv_l}{J}\left(\frac{\beta}{T} - \gamma\right)$.

" B. $C = 0{\cdot}03369359 - (6{\cdot}472055 \times 10^{-6})\,t + (1{\cdot}405694 \times 10^{-8})t^2 - (6{\cdot}57293 \times 10^{-12})\,t^3$.

" C. $C = 0{\cdot}03351 - 0{\cdot}000003852\,t$.

Temperature. Deg. F.	Sensible Heat by Formula—		
	A.	B.	C.
100	2·25415	2·26647	2·26141
200	5·56910	5·56910	5·55463
300	8·88422	8·85485	8·80933
400	12·20029	12·14231	12·02552
500	15·51963	15·44573	15·20317
600	18·84742	18·77542	18·34231
700	22·19248	22·13758	21·44292

In a paper on "Molecular Attraction,"* Mills examines, at some length the question of specific heats from the molecular standpoint, and calculates a series of values which have been included in Table IV. Whilst these are somewhat higher than the experimental values and vary in a less degree, they display the same features as those of Barnes in a qualitative manner, that is, they have a minimum value between 300 deg. and 400 deg. F.

7. *The Critical Temperature and Pressure of Mercury.*—The critical temperature of mercury is that temperature above which, however great the pressure employed, it is impossible to liquefy the mercury vapour. The minimum pressure, which is just sufficient to cause the vapour to liquefy at the critical temperature, is called the critical pressure. The critical pressure is so high that it is only of interest to us in one respect, namely, that at the critical pressure the latent heat of vaporisation is zero. Provided a satisfactory relationship between the temperature and vapour pressure at temperatures approaching the critical can be obtained, the critical pressure and temperature (p_c and T_c) may be calculated from the empirical vapour-pressure formula of Van der Waals :—

$$\log \frac{p_c}{p} = f\left(\frac{T_c}{T} - 1\right) \quad . \quad . \quad (10)$$

Although f is regarded as a universal constant, it is only approximately constant for "normal" substances. A few values of f are set out in Table VI.

For polymerised or associated substances, the value of f is higher; for example, for water, f is 3·26. Mercury which is monatomic at normal temperatures, is polymerized at temperatures above 500 deg. C. (932 deg. F.). being represented by the formula Hg_2. Thus, unless it

TABLE VI.—*Values of f in Van der Waals' Equation.*

"Normal Substances."

Substance.	Nature.	f.
Argon	Monatomic ..	2·415 (at −140·8 C.), 2·577 (at 125·0 C.)
Krypton	Monatomic ..	2·39
Xenon	Monatomic ..	2·38
Hydrogen ..	Diatomic ..	2·10
Nitrogen ..	Diatomic ..	2·27
Oxygen	Diatomic ..	2·50
Carbon dioxide ..	Triatomic ..	2·86

can be assumed that in the range of temperature for which the calculation is made, the value of f remains constant, the critical temperature calculated by this method would only be approximate. If f remains constant over the range, it is clear that the formula of Van der Waals may be rewritten—

$$\frac{\log p_1 - \log p_2}{\log p_c - \log p_2} \cdot \frac{T_2}{T_1} \cdot \frac{T_c - T_1}{T_c - T_2}$$

Where T_1 and T_2 are two temperatures within the range. Applied to mercury at the boiling point (677 deg. F.) and 932 deg. F., the value of p_c was found by Van Laar to be 204 atmospheres.* Van Laar considers this value to be too high, due to the increase of f between 677 deg. F. and 932 deg. F. By calculating T_c, p_c and f, using values of p at three different temperatures, he arrives at the conclusion that $T_c = 1{,}242$ deg. C. absolute (2,235·6 deg. F. absolute), and $p_c = 187$ atmospheres.

In a later paper† Van Laar re-calculates the critical data for mercury, on the basis of the vapour-pressure determinations of Cailletet, Colardeau, and Rivière. The method outlined above was again used, with the following results :—

$T_c = 1{,}172$ deg. C. abs. = 2,109·6 deg. F. abs.
$p_c = 180$ atmospheres.

On the other hand, in a paper on "The Critical Temperature of Mercury,"‡ Julie Bender estimates that the critical temperature lies between 1,500 deg. and 1,600 deg. C. (2,732 deg. and 2,912 deg. F.), and that the critical pressure is considerably greater than 180 atmospheres. The critical data for mercury are, therefore, somewhat conjectural.

8. *The Latent Heat of Vaporisation.*—Here, again, there is a dearth of experimental data, and the only published figure known to the author is the latent heat of vaporisation at the boiling point, namely, 68 C.H.U., or 122·4 B.Th.U., at 677 deg. F. If the specific volume of mercury vapour were known accurately the latent heat could be calculated directly from Clapeyron's equation—

$$L = \frac{dP}{dT} \cdot \frac{T}{J} \cdot (v_m - v_l).$$

The value of $\frac{dP}{dT}$ may be obtained directly from the vapour-pressure equation—

$$\log P = a - \frac{\beta}{T} - \gamma \log T,$$

that is,

$$\frac{dP}{dT} = P\left(\frac{\beta}{T^2} - \frac{\gamma}{T}\right),$$

from which

$$L = \frac{P}{J}\left(\frac{\beta}{T} - \gamma\right)(v_m - v_l) \quad . \quad (11)$$

In the absence of any data regarding the specific volume of mercury vapour, other methods of calculation must be obtained. The following expression, known as the Clausius-Clapeyron equation, is obtained by combining the Clapeyron equation and the characteristic equation for an ideal gas—

$$L = \frac{R \cdot T_1 \cdot T_2}{T_2 - T_1} \cdot \log_e \frac{P_2}{P_1} \quad . \quad . \quad (12)$$

This expression has been modified by Nernst by the addition of a multiplying factor $\left(1 - \frac{P}{P_c}\right)$, where P is the saturation pressure and P_c the critical pressure. In the above formula P_1 and P_2 represent the respective vapour pressures corresponding to T_1 and T_2, two temperatures which differ by so small an amount that their geometrical and arithmetical means may, for practical purposes, be said to equal one another. This mean temperature is the one to which L corresponds. Nernst's formula becomes—

$$L = \frac{R \cdot T_1 \cdot T_2}{T_2 - T_1} \cdot \log_e \frac{P_2}{P_1} \cdot \left(1 - \frac{P}{P_c}\right) \quad . \quad (13)$$

That equation (12) could not be applied at very high

* Journal of Physical Chemistry, 1917, vol. xxi, page 345.

* Journal of Physical Chemistry, 1917, vol. xxi, page 345.

* Fundamental values of the quantities b and $\sqrt{a}$ for various elements in connection with the periodic system (Mercury). J. J. Van Laar, Verlag. Akad. Wetenschappen, 24, 1916.

† The Critical Temperature and Pressure of Mercury. Proc. Acad. Sci. Amsterdam, 1917, xx, pp. 138–148.

‡ *Physik Zeits.*, 19, pages 410–414, 1918.

pressures is obvious, in view of the nature of the assumptions on which it is based. Nernst's equation is apparently an attempt to correct for the departure from the criteria for a perfect gas, the correction being based upon the fact that the latent heat is zero at the critical pressure. It is generally considered that equation (13) would give results as accurate as, if not more accurate than, those obtained calorimetrically.

Nernst's equation is not convenient in use, and for the purpose of constructing the tables the author has used the expression—

$$L = R(\beta - \gamma T) \quad . \quad . \quad . \quad (14)$$

which gives precisely the same results as (12). Equation (14) is obtained by combining Clapeyron's equation, the characteristic equation, and the vapour-pressure formula of Hertz.

By Clapeyron's equation we have—

$$L = \frac{dP}{dT} \cdot \frac{T}{J} (v_m - v_l).$$

For all but very high pressures, v_l is small compared with v_m, and, further, it is assumed that $P v_m = J R T$. Then

$$L = \frac{dP}{dT} \cdot \frac{T}{J} \cdot v_m = \frac{R T^2}{P} \cdot \frac{dP}{dT}.$$

From the vapour-pressure formula of Hertz, that is,

$$\log p = a - \frac{\beta}{T} - \gamma \log T.$$

$$\frac{dP}{dT} = P\left(\frac{\beta}{T^2} - \frac{\gamma}{T}\right).$$

$$\therefore L = R(\beta - \gamma T).$$

Owing to the uncertainty of the critical pressure data available, the correction factor $\left(1 - \frac{P}{P_c}\right)$ has been omitted throughout. If the critical pressure be as low as Van Laar states, then the correction would be fairly considerable, amounting to about 1·7 per cent. at 800 deg. F., 3·5 per cent. at 900 deg. F., and 6·6 per cent. at 1,000 deg. F. It is not certain that these figures represent actual errors. It is quite possible that, with a suitable adjustment of the constants, a formula of this type would represent the latent heat at even high temperatures with quite a small error.

By substituting the correct values of R, β and γ, the following equations were obtained. These have been used in the construction of the tables.

Below the boiling point (677 deg. F.)

$$L = 133{\cdot}2771 - 0{\cdot}00967505t \quad . \quad (15)$$

Above 677 deg. F.

$$L = 131{\cdot}0858 - 0{\cdot}0064354t \quad . \quad (16)$$

9. *Specific Volume of the Vapour.*—In the complete absence of any data regarding the specific volume of the vapour, the values given in the Table of Properties were calculated from the characteristic equation—

$$v_m = \frac{0{\cdot}05347\,T}{p} \quad . \quad . \quad (17)$$

in which

v_m = specific volume of mercury vapour in cubic feet per lb.

T = absolute temperature (Fahrenheit units).

p = absolute pressure in lbs. per square inch.

10. *Superheated Mercury Vapour.*—According to the Kinetic Theory of Gases, the value of $m K_v$ for a perfect gas is 3/2 R, and of $m K_p$ is 5/2 R, m being the molecular weight of the substance and R the universal gas constant (1·985 B.Th.U. per degree F.). This is also true of a truly monatomic gas, since the whole of the molecular energy is translational kinetic energy. The theoretical value of the molecular specific heat at constant volume is, therefore, 2·9775, and the value of γ, the ratio of the specific heat at constant pressure to the specific heat at constant volume is $\frac{5}{3}$, or 1·6666. The good agreement between the theoretical values and the experimental values may be observed by reference to Table VII.

Hence, within the range of experiment,

$$K_p = \frac{5}{2} \times \frac{1{\cdot}985}{200{\cdot}6} = 0{\cdot}024738.$$

At higher temperatures, where the molecules are partly associated, it is probable that the specific heat has a higher, and γ a lower value. The superheat, Table XI of the paper (not reproduced.—Ed. E.), has been calculated on the assumption that K_p is constant.

TABLE VII.—*Experimental Values of $m K_v$ and γ for Monatomic Substances.*

Gas.	Temp.	$m K_v$	γ	Observer.
	deg. F.			
Helium	5-302	3·01	1·63	Benn and Geiger, 1907.
Argon	32	2·997	1·667	Niemeyer, 1902.
Neon	66	—	1·642	Ramsay, 1912.
Krypton	66	—	1·689	Ramsay, 1912.
Xenon	60	—	1·666	Ramsay, 1912.
Mercury vapour	527–673	2·979	1·666	Kundt and Warburg, 1876.

11. *Calculation of Tables of Properties.*—Having discussed the various sources of data, there remains little to be said regarding the calculation of the properties. The calculations were first made on a temperature basis, the vapour pressure being calculated for every 10 deg. F. from 32 deg. F. to 1,000 deg. F. The specific heat of the liquid was next calculated at frequent intervals of temperature by means of equation (8) and set down on a series of graphs having a size equivalent to one graph 14 ft. by 12 ft. The sensible heat of the liquid was then calculated by a "step-by-step" process for every 10 deg. F. and integrated arithmetically. The latent heat was calculated directly for every 10 deg. F. by means of equations (15) and (16). The changes of entropy during the addition of sensible heat were calculated for 10 deg. F. intervals and also integrated arithmetically, whilst the change of entropy during vaporisation was calculated at every step. The whole of these properties were then laid down on the above-mentioned series of graphs and the pressure tables compiled directly from the graphs.

A total heat-entropy diagram* is shown in Fig. 7, while the more useful portion of the diagram is reproduced in Fig. 8.

12. *The Flow of Mercury Vapour through Nozzles.*—In order to obtain a relationship between the pressure and volume during the adiabatic expansion of mercury vapour, values of log p have been plotted against the values of log v. Frictionless flow in thermal equilibrium has been assumed throughout. If the relationship could be expressed by the equation: pv^n = constant, where n is a constant, then the plotted points would lie on parallel straight lines, whatever the initial pressure. It is found that n is a function of the initial temperature, and, moreover, that the log p — log v graph is not a straight line but a very flat curve as shown in Fig. 9, which is drawn to scale for an initial temperature of 1,000 deg. F.; $a\,b$ is the log p — log v curve and $a\,c$ the straight line drawn through the points representing 180 lb. per square inch and 90 lb. per square inch abs. The exact slope of such lines as $a\,c$ was calculated in each instance and not obtained graphically. If two points on the curve $a\,b$, representing the initial and final conditions during an adiabatic expansion with a given pressure ratio, be joined by a straight line, the slope of that line given by the ratio:

$$\frac{\log p_1 - \log p_2}{\log v_2 - \log v_1}$$

will represent the mean value of n for the given pressure ratio. Such values of n, calculated for varying initial temperatures of dry saturated mercury vapour and pressure ratios of 2, 10 and 100, are shown graphically in Fig. 10. There is a straight-line relationship between n and the initial temperature t, and hence the correct form of the adiabatic equation is $p v^{at+b}$ constant, where a and b are themselves functions of the pressure-ratio of expansion. There is thus no simple connection between p and v during an adiabatic expansion.

In order to calculate the throat area of nozzles required

Fig. 7. COMPLETE TOTAL HEAT-ENTROPY DIAGRAM FOR MERCURY.

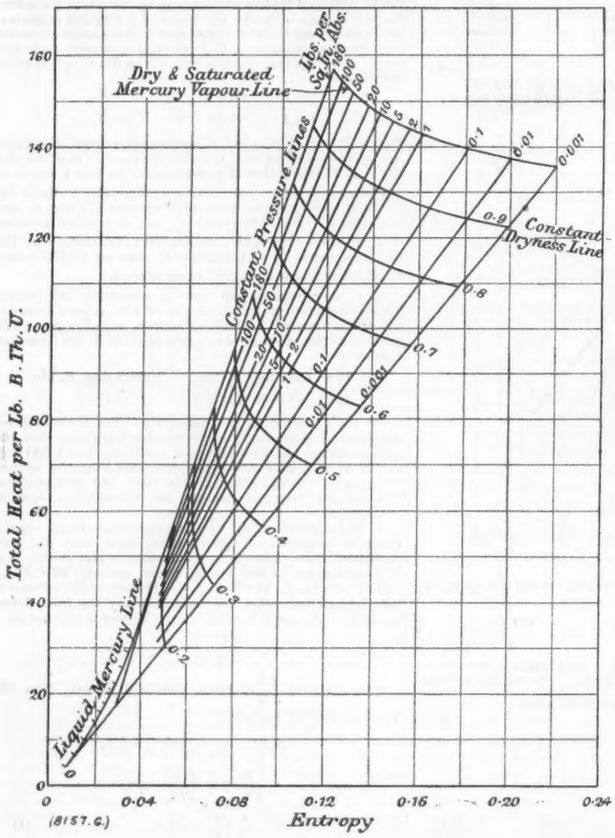
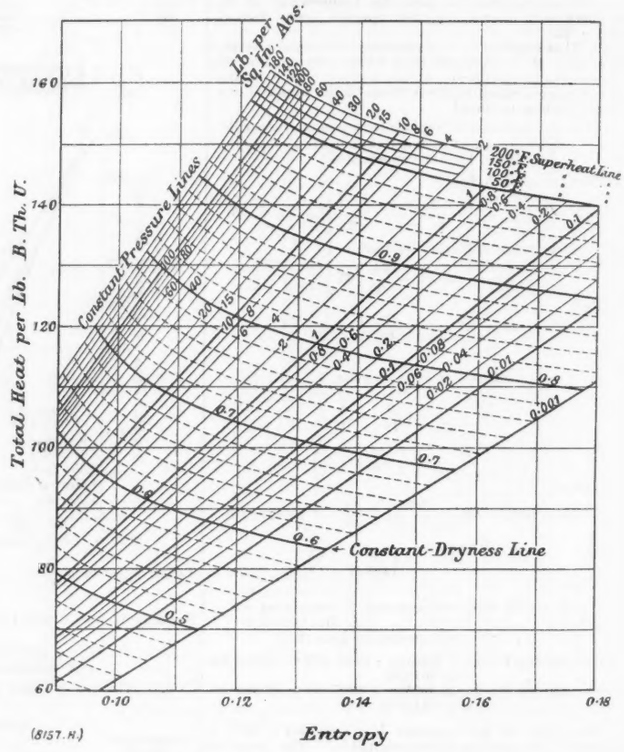


Fig. 8. TOTAL HEAT-ENTROPY DIAGRAM FOR MERCURY.



* The two original charts, Fig. 7, 1¼ times larger, and Fig. 8, 3½ times larger, each containing many intermediate curves, may be consulted in the Library of the Institution of Mechanical Engineers.

to pass a given mass of mercury vapour, the critical pressure-ratio r has been calculated by means of the well-known expression—

$$r = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

and set down in Fig. 10. There is a linear law connecting r and t expressed by the formula—

$$r = 0{\cdot}5882 - 0{\cdot}000029\,t\ \text{F.}$$

The weight of vapour discharged through a nozzle with adiabatic and frictionless flow, according to the equation $p\,v^n$ = constant, may be calculated by means of the expression—

$$w = \frac{A_t}{12}\sqrt{\frac{2\,g\,n}{n-1}\cdot\frac{p_1}{v_{m1}}\left\{\frac{2}{r^n} - r^{\frac{n+1}{n}}\right\}}$$

in which

w = weight of mercury discharged in lbs. per sec.
A_t = throat area of nozzle in square inches.
n = index of v in $p\,v^n$ = constant.
p_1 = initial pressure in lbs. per square inch abs.
v_{m1} = initial specific volume of vapour in cubic feet per lb.
r = critical pressure ratio.

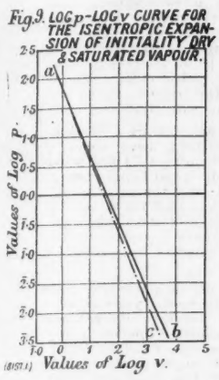


Fig.9. LOG p-LOG v CURVE FOR THE ISENTROPIC EXPANSION OF INITIALITY DRY & SATURATED VAPOUR.
Values of Log p
Values of Log v.
(8157.I.)

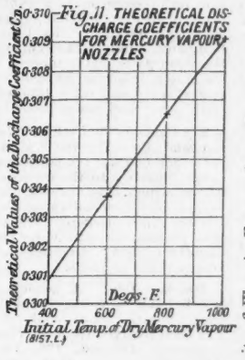


Fig.11. THEORETICAL DISCHARGE COEFFICIENTS FOR MERCURY VAPOUR NOZZLES
Theoretical Values of the Discharge Coefficient
Degs. F.
Initial Temp. of Dry Mercury Vapour
(8157.L.)

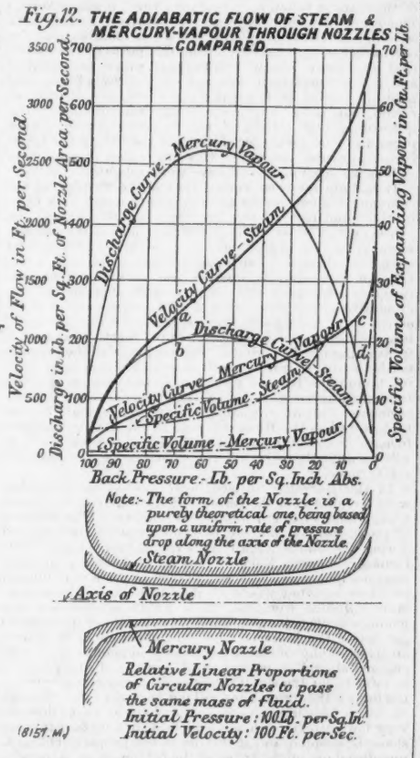


Fig.12. THE ADIABATIC FLOW OF STEAM & MERCURY-VAPOUR THROUGH NOZZLES COMPARED.
Velocity of Flow in Ft. per Second.
Discharge in Lb. per Sq. Ft. of Nozzle Area per Second.
Specific Volume of Expanding Vapour in Cu. Ft. per Lb.
Discharge Curve - Mercury Vapour
Velocity Curve - Steam
Discharge Curve - Steam
Velocity Curve - Mercury Vapour
Specific Volume - Steam
Specific Volume - Mercury Vapour
Back Pressure - Lb. per Sq. Inch Abs.
Note:- The form of the Nozzle is a purely theoretical one, being based upon a uniform rate of pressure drop along the axis of the Nozzle.
Steam Nozzle
Axis of Nozzle
Mercury Nozzle
Relative Linear Proportions of Circular Nozzles to pass the same mass of Fluid.
Initial Pressure: 100 Lb. per Sq. In.
Initial Velocity: 100 Ft. per Sec.
(8157.M.)

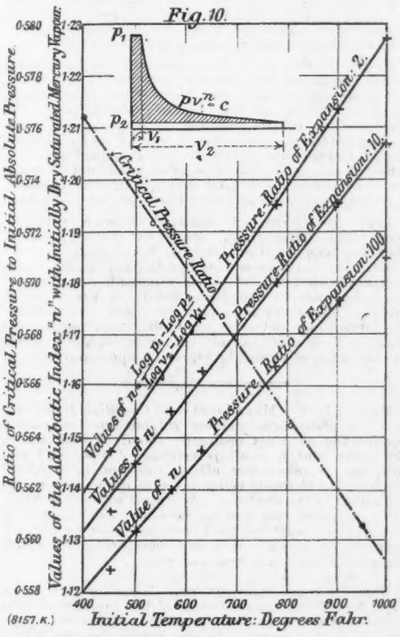


Fig.10.
Ratio of Critical Pressure to Initial Absolute Pressure
Values of the Adiabatic Index "n" with Initially Dry Saturated Mercury Vapour.
Critical Pressure Ratio.
Pressure Ratio of Expansion: 2.
Pressure Ratio of Expansion: 10.
Pressure Ratio of Expansion: 100.
Values of n - Log p1/p2 - Log v1/v2
Values of n
Value of n
Initial Temperature: Degrees Fahr.
(8157.K.)

This expression may be written

$$w = C_D \cdot A_t \cdot \sqrt{\frac{p_1}{v_{m1}}},$$

where

$$C_D = \frac{1}{12}\sqrt{\frac{2\,g\,n}{n-1}\cdot\left\{\frac{2}{r^n} - r^{\frac{n+1}{n}}\right\}}.$$

In order to show the variation in C_D, which may perhaps be termed a coefficient of discharge, values have been calculated and plotted in Fig. 11. The variation of C_D within the range from 400 deg. F. to 1,000 deg. F. is 0·008, or about 3 per cent.

The values of the critical pressure-ratio are about the same as those for steam, which are 0·577 and 0·5457 for dry saturated and for superheated steam, respectively. Whilst the critical heat drop for steam is about 45 B.Th.U. and the critical velocity about 1,500 ft. per second, those for mercury vapour are only about 7·6 B.Th.U. and 610 ft. per second respectively. If it be assumed that the blade velocity in the mercury vapour turbine would be similar to that in a steam turbine, that is, about 500 ft. per second, the velocity of the mercury vapour at exit would require to be in the neighbourhood of 1,200 ft. per second. That this involves a nozzle having a considerable amount of divergence will be apparent from Fig. 12, in which curves of velocity, specific volume and discharge per unit area are set out on a base of back pressures. The conditions which are assumed are—

(*a*) Mass flow per second: 1 lb.
(*b*) Initial pressure: 100 lb. per square inch abs.
(*c*) Initial velocity at entry to nozzle: 100 ft. per second.

The mechanical construction of the mercury-vapour impulse-turbine is thus unavoidably complicated by the use of convergent-divergent nozzles, although this disadvantage may be more than outweighed by the smaller number of stages required, as will be shown later.

Although the velocity of mercury vapour is less than that of steam for the same back-pressure, the specific volume is less still, with the result that the mass discharge of mercury vapour is two and a-half times that of steam per unit area of nozzle throat. It might thus appear that, under working conditions, a mercury vapour nozzle of a given size would discharge more than twice as much as a steam nozzle of equal size. The size of a turbine nozzle, which is the criterion in deciding the possible mass flow of fluid through it, is not necessarily the throat area, although it usually is in steam turbines, since the pressure drop is not usually greater than the critical, except in velocity-compounded stages. From what has just been said, it is obvious that in the mercury vapour turbine, the area which is important is the exit area. In this respect, whether the mercury nozzle or the steam nozzle will discharge the greater mass in a given time depends upon the exit velocity required. This may be followed by reference to Fig. 12.

Suppose, in the first instance, that the exit velocity is to be 1,200 ft. per second. Taking the point *a* on the steam velocity curve and drawing the vertical *a b*, it is obvious that the steam pressure at exit will be about 70 lb. per square inch and the discharge per square foot of exit area 200 lb. per second. Now, if we take the point *c* on the mercury velocity curve and draw the vertical *c d*, it is apparent that the pressure at exit is about 7·5 lb. per square inch absolute and the discharge only 182 lb. per second per square foot of exit area. With an exit velocity of 1,000 ft. per second, the situation is reversed, the discharge being 182 lb. for the steam and 330 lb. for the mercury nozzle. A relatively low exit velocity, which would also probably give a more favourable value of the ratio of blade speed to jet speed, would seem to be preferred for mercury in cases where the question of exit area is vital. This may be regarded as a general principle which does not arise in steam turbine practice.

(To be continued.)

THE BARBER-GREENE TRENCH DIGGER: ERRATUM.—We regret that on page 593 *ante* we gave the name of the representatives in this country of the Barber-Greene Company incorrectly. The firm in question is the Allied Machinery Company, Limited, 70, Victoria-street, S.W. 1.

PROGRESS IN BLAST-FURNACE WORK.*

By P. H. ROYSTER, T. L. JOSEPH, and S. P. KINNEY.

AN investigation of the production of iron in the blast-furnace is obviously not an easy subject for research. Enough is known of the mechanical, thermal and chemical conditions existing inside the furnace to say certainly that they are complicated. Furnace operators have found that the process is sensitive to a number of known and to many unknown operating conditions. In order to form any conclusions of value, it seems necessary to collect a large amount of data taken with considerable care and accuracy. These facts make a blast-furnace research difficult but not impossible. The most serious obstacle in attacking the problem comes from the fact that it is useless in the design and operation of the blast furnace to use the method of "trial and error," which has proved valuable in so many other industrial problems. The variables are so interrelated and are so dependent one on the other that the number of experimental combinations to be tried is enormous. There are certainly not less than 20 factors in furnace operation and design that are known to influence the results. This is apparent if it is remembered that a phrase like "size and shape of the furnace" includes height of the furnace, height, diameter and angle of the bosh, inwall batter, stockline diameter, and furnace volume; and that a phrase like "chemical and physical properties of the fuels charged" includes size and shape of the lumps, density, porosity and strength of the coke, in addition to its chemical analysis. Let us suppose that we need choose for each of 20 factors one of two values; for example, suppose we must say only that the furnace shall be "tall" or "short," that the bosh angle shall be "flat" or "steep," that the ore shall be "coarse" or "fine," or that the blast has to be "hot" or "cold," the number of resulting combinations is more than 1,000,000. It is obvious, therefore, that some sort of mathematical relationship, a set of rules of thumb, laws, curves, or the like, are needed. Whether the relationships, curves, or formulæ are derived from experiment, from theory, or from mere guess-work, makes no difference provided they agree with the known facts. If they do not agree with known facts, they are worthless no matter what their origin or how weighty the "authority" vouching for them. Few such relationships have appeared in blast-furnace literature, and it may be doubted whether such formulæ can be discovered.

In spite of the difficulty of the problem a large amount of research on the blast-furnace process has been done. The motives inspiring the investigators have been various and interesting. The commercial necessity of utilising new or modified furnace materials has been predominant. For example, it has been desirable in the course of time to use four fuels, charcoal, anthracite, soft coal and coke. Whenever a change in fuel has been made, it has been necessary to find as quickly and as cheaply as possible some combination of furnace lines and operation that would permit continuing commercial practice at a profit with the materials and plant equipment available at the time. Few, if any, attempts have been made to determine fundamental relationships of general value to the industry.

The Department of the Interior has been investigating the blast-furnace process since 1916. The conduct of this research, carried out by the metallurgical division of the Bureau of Mines, has not been simple. None of the possible methods of investigation has appeared promising. Three kinds of study have been tried. It has been found convenient to label these plant observations, laboratory research, and experimental blast-furnace operation. The first two, though easy to carry out and productive of a large amount of data, will not go far toward finding the real answer of the problem. The last one, operation of an experimental blast furnace, promises an approach to the blast-furnace process in a most direct manner. In abstract, an experimental blast furnace is one in which the conditions encountered in commercial practice are duplicated on a smaller scale, and one in which the process can be conducted with a variety of operating conditions in order that practical conclusions useful to the industry may be arrived at. Actually, no such furnace existed, and from the literature it appears that none had ever existed, although no reason seems to have been set forth why such a furnace could not operate. It must be admitted that after the Bureau of Mines had built and attempted, but failed to operate a score of experimental furnaces, the conviction was entertained by many that such a furnace was practically impossible. During the whole research, however, no evidence was found to indicate that large furnace size is metallurgically necessary to the blast-furnace process. The first of these experimental furnaces was 16 ft. tall. Later ones were built as short as 10 in. and as tall as 21 ft. The hearth diameter has been varied from 1 in. to 4 ft. There has been nothing to indicate that any basic difference exists between these small furnaces and furnaces of commercial size. The Bureau has obtained its best results with a hearth diameter of 20 in., which happens to be about half-way between the largest and smallest tried. No significance, of course, can be attached to anything like this, a single furnace dimension, unless its relationship to operating conditions, to materials used and to other furnace dimensions is considered.

Since 1919 the Bureau of Mines has constructed and blown in 35 experimental furnaces at its North Central Experiment Station, Minneapolis. The primary object in designing and operating these furnaces was to establish working principles to aid the Bureau in its own experimental work. Enough progress has been made, however, to say that the experimental blast furnace is now an

* Report issued by the United States Bureau of Mines.

established and proven piece of research equipment. Since the natural complexity of the process renders the standard method of "trial and error" useless in blast-furnace research, it has been necessary to proceed along technical lines, in outlining plant investigations, in directing laboratory work, and in operating the experimental blast furnaces, and to employ a certain amount of abstruse mathematical analysis in interpreting the results obtained. The method of investigation required from the outset that the chemical and physical conditions obtaining in the furnace be known, and the first work of the Bureau was devoted to that part of the problem.

Observations were made at commercial furnace plants* to find out at what temperature the metal and the slag was discharged from the furnace, and the temperature of the lumps of coke burning at the nose of the tuyeres. The investigation covers not only the production of basic bessemer and foundry irons, but also spiegeleisen, ferro-manganese† and charcoal iron.‡ The analysis of the slags from these furnaces was of course recorded, and the fluidity of such slags has been measured in the laboratory.§ This work established the fact that blast-furnace slags are so hot and so fluid that the so-called "free-running" temperature is of negligible importance in furnace operation. This discovery was obviously a most satisfying step in simplifying the blast-furnace problem, but its industrial importance lay largely in the fact that enormous tonnages of ores previously believed to be too refractory for blast furnace use were shown to be readily adapted to smelting in the blast furnace.

In another plant investigation water-cooled gas-sampling tubes were driven into and across the combustion zone of a number of furnaces, and the place where the fuel burned was determined.‖ This was found in each test to be within about a yard stick's length of the air inlet, no matter what character of fuel was used. Experiments carried out in the Bureau of Mines laboratory have verified this result.¶

The work involved in these investigations at blast-furnace plants and in the Bureau's laboratories has not been small, and the results obtained, adaptable as they are in a direct manner to the blast-furnace process, are of great industrial importance. They indicate the commercial feasibility of using in various parts of a country mineral resources locally available—a requirement essential to the enduring success of any industry. As these results become better known, their industrial value will grow. Ores and fuels will be applied to metallurgical uses which have been employed less efficiently in other industries, or, irretrievably lost in waste piles. For one thing, this work sets up a criterion for judging the metallurgical value of fuels; it has shown the coke-oven operator the impossibility of changing coke "combustibility" by modifying oven practice; and by diverting attention from this, it has inspired research relating to other properties of coke. It has also solved problems, many of them imaginary, in the smelting of those ores supposed to produce the so-called "infusible," "refractory" and "unmanageable" slags. It has done more. By removing slag composition from the ore problem, it has concentrated attention on the important question of ore reduction, and in blast-furnace research this question is now receiving more nearly the attention it has always deserved.

During the past year the results obtained in the operation of the experimental furnace at Minneapolis have been so far-reaching that the aspect of the problem has been considerably changed. Unless the Bureau is able to prove that its data are incorrect—and it is trying to do this—the whole trend of blast-furnace research will have to be altered. The experimental furnace is less than one-quarter of the standard height (75 ft. to 100 ft.) adopted in England fifty years ago. All the furnaces built since the "metallurgical revolution of 1870" have copied the height used at that time. In the following half century commercial practice, industrial development and technical research have changed nearly every other detail of design, of construction and of operation. Blowing equipment, stoves, method of charging materials and means for disposing of products have been improved to such extent that the goal of quantity production has been attained. Tonnages from furnace units have been increased fivefold and at the same time the actual amount of labour employed has been reduced. Progress during this past fifty years of iron-making has been great, but it has been mechanical and industrial progress, rather than metallurgical. The modern American blast furnace with its stoves costs less than one-fifth of the total cost of the furnace plant.* It is as cheap to tear down and rebuild five furnaces as it is to modernise the equipment of one. To-day many furnaces are rather inefficient in their blowing, preheating, gas and material handling equipment. Blast-furnace engineers, however, are available with the knowledge, skill and experience necessary to bring the equipment of these plants to such a degree of efficiency that the fundamental metallurgy of the process will again become the weakest link in the chain. The more recent results of the Bureau's research, therefore, are of particular interest at this time.

Although the greatest height of any of the Bureau's experimental furnaces was 20 ft., it was found that in a large part of the furnace no useful physical or chemical changes were taking place. All the coke charged was burned by air within a foot or so of the blast entrance, and in that region the heat necessary to the process was generated and the gas needed to convert the ore into metal was formed. As this gas was forced upward through the crevices between the solids filling the furnace, it did not change in composition until it was almost at the stock line. Here the gas encountered the descending ore and changed it into metal with great rapidity. All the reduction of ore that took place in the furnace occurred in this upper fraction of the furnace. Between the region of combustion at the bottom and this region of ore-reduction at the top, there existed a large portion of the furnace which may be called the "inactive zone." The adjectives, idle, neutral or negative, might serve as well. If it be remembered that a considerable quantity of heat is lost by conduction from this part of the furnace, that expensive blowing equipment must be installed and power urgently in demand by the rest of the steel plant is needed to force the gas through this inactive region, all these adjectives seem inadequate, if not misleading. Of course, if this inactive region should prove to be necessary for the proper conduct of the blast-furnace process, the use of this power and the purchase of blowing equipment will have to be tolerated.

It has always been known that if the burning of the coke and the conversion of the ore into metal took place in the same part of the furnace, the efficiency of the process would suffer. These two functions of the furnace, namely, the reduction of ore and the combustion of coke, are chemically antagonistic and definitely should be kept separate. It was for this reason in fact that furnaces were built tall. The French even named the apparatus a *haut-fourneau* and the Germans called it the equivalent, *Hochofen*. The expression "tall furnace," has not been used in English, but "blast" was put in front of the word "furnace," in recognition of the pressure needed to drive air into a tall furnace. There is good cause for building a furnace tall enough to separate the two fundamental functions of the blast furnace into distinct regions so that no overlapping or mixing occurs. Nevertheless, unless the Bureau is able to prove that its 20-ft. furnace is so short that overlapping does take place, it will be difficult to justify the existence of the standard tall furnace.

In the Bureau's furnace, water-cooled sample tubes were forced across the furnace at six different levels and a large number of gas samples were taken. The analyses of these samples indicate that the inactive zone existed during the course of all the experiments on the 20 ft. furnace. Various kinds of ore were charged; in some tests ore in lumps averaging an inch or more in diameter, in others ore that would all pass through a ¼ in. screen. Manganiferous iron ore, from which spiegeleisen was made, was also charged, but in no test was it possible to get rid of the inactive zone. In a commercial furnace an overlapping of these zones may happen. If the ore charged should be composed of lumps and fine particles so mixed that the small particles fill the crevices between the lumps, the furnace gas will not be able to pass through the ore. This might allow the unchanged ore to descend very low into the furnace. In fact, if a certain furnace shape is adopted and if the ore is not properly charged, unreduced ore might arrive at the bottom of an extremely tall furnace. On the other hand, if the naturally rapid combustion of the coke were interfered with, the zone of combustion might move upward.

The course of the Bureau of Mines' research thus far has been in the opposite direction, and the purpose in its furnace design and operation has been to locate combustion at the blast entrance and to concentrate the conversion of ore into metal at the stock line. This was done because of the obvious commercial advantages of the short furnace and because of a widespread doubt as to the ability of small furnaces to make iron.

However, the principal object of the research is to find out the basic metallurgical facts of the blast-furnace process, and studies should be made to ascertain why in an 80-ft. furnace, overlapping of these two zones of the furnace sometimes appears to take place.

The writers are somewhat hesitant about describing the existence of the inactive zone found in the Bureau's furnace. It does not follow that a height of 80 ft. or 90 ft. is unnecessary in the present state of the industry. It should not be overlooked, however, that a shortening of the furnace may be accomplished if accompanied by suitable changes in operation and design. The Bureau's furnace, although short and with only a 20-in. hearth, has made 3 tons of pig-iron per day and can make either less or more than that if desired. It is, in fact, a blast furnace, and in its operation there are exactly the same number of variables and the same millions of combinations of variables as are found in the operation of a commercial unit. The "try and see" method of investigation is therefore meaningless in either case. It is the hope of those engaged in this research that by focussing attention on the metallurgical principles and by forgetting tonnages and costs, something in the way of fundamental principles will be discovered. Saying this the other way, no one who has had actual experience with the experimental furnace is optimistic enough to think that progress can be made by the "try and see" method. If valuable results are to come from the research, these results will be in the form of relationships far from simple; not easily explained and probably not expressible at all except in mathematical language. The significance will not be easily understood except by technically trained men. It is primarily for the purpose of explaining why this is true, and of describing as simply as may be the present status of blast-furnace metallurgy, the peculiar character of its problems, and the nature of its future progress, that this paper has been written.

* "Pyrometry in Blast-Furnace Work," by P. H. Royster and T. L. Joseph. Vol. on Pyrometry, A.I.M.E., 1920, pages 544 to 558. Discussion, pages 558 to 567.

† "Production of Ferro-manganese in the Blast Furnace," Bull. 173, Bureau of Mines, Trans. A.I.M.E., 1920. Vol. lxii, page 18.

‡ "Temperatures in Charcoal Blast Furnaces," T. L. Joseph. Unpublished.

§ "Slag Viscosity Tables for Blast-Furnace Work," A. L. Field and P. H. Royster. Trans. A.I.M.E., vol. lviii. 1918., page 650. Bureau of Mines Technical Paper 187. "Temperature Relations in the Ternary System CaO–Al_2O_3–SiO_2. by A. L. Field and P. H. Royster. Trans. A.I.M.E., vol. lviii, page 658, Bureau of Mines Technical paper 189.

‖ "Combustion of Coke in the Blast-Furnace Hearth," G. St. John Perrott and S. P. Kinney. Paper No. 1222–S, presented at February meeting of A.I.M.E. Abstracted, *Mining and Metallurgy*, March 1923, page 145.

¶ Bureau of Mines' Technical Papers 137, 139, 207. "Combustion of Blast-Furnace Cokes in Fuel Beds," Sherman and John Blizard, Paper No. 1217–S, presented February meeting of A.I.M.E. Abstracted, *Mining and Metallurgy*, February, 1923, page 93. Sherman and S. P. Kinney, *Iron Age*, June 28, 1923.

* "Iron-making Economies Developed in 1922," F. H. Wilcox, *Iron Age*, January 4, 1923, page 84.

CATALOGUES.

Switch Gear.—Three catalogues dealing with protective panels for crane motors on alternating and direct-current circuits, auxiliary current limiting switches and push-button switches, have come to hand from the British Thomson-Houston Company, Limited, Rugby. The catalogues have been carefully compiled and they contain all the information a buyer is likely to require.

Induction Motors.—Induction motors of the protected type for pressures up to 650 volts, and ranging from about 6 b.h.p. to over 300 b.h.p., are the subject of a special catalogue issued by the Brush Electrical Engineering Company, Limited, Loughborough. A specification of the main parts of the motors, table of temperature rise, dimension tables in English and metric units, tables of power, speed and rotor data, of shipping dimensions and of efficiency and power factor, are given in all cases.

Try-Cocks for Boiler Water Gauges.—Messrs. J. Hopkinson and Co., Limited, Huddersfield, have issued a catalogue of their try-cocks for blowing off boiler water gauge glasses. In these cocks the usual handle rotates a cam which lifts a valve, and after the valve is well open it lifts a second valve which is normally held down by the boiler pressure. The object of the upper valve is to protect the main valve face from scoring when it is slightly opened. Adapters are supplied for connection to any make of gauge.

Hammer Drill.—A catalogue of the pneumatic tools which have been largely used in recent years in connection with road repairs for breaking up concrete has been received from the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W. 1. The drills used are either of the solid peg point or hollow rose bit types, both made from 1-in. hexagonal steel. A similar form of spade tool for digging heavy clay, &c., is illustrated. These tools are supplied complete with portable air compressor, hose, &c.

Drying Machines.—A sheet illustrating eight different drying machines for various materials produced in chemical and similar works is to hand from Messrs. Manlove, Alliott and Co., Limited, Nottingham. The machines are variously suited to batch or continuous feeding, extracting whatever degree of moisture is required, and they are operable with heat applied in various different manners. The firm offer to submit a design for drying any given kind and quantity of material, employing whatever source of heat may be available.

Light Locomotives.—A catalogue of spare parts for their light locomotives, issued by Messrs. Andrew Barclay, Sons and Co., Limited, Kilmarnock, gives an illustration and reference number for each separate part, together with tables of capacity and illustrations with reference lines to the parts listed. A few pages of practical notes are appropriately added giving advice on lubrication, detection of faults, adjustments, &c. Many of these small locomotives are in use abroad where the list referred to will be especially appreciated.

MAYARI IRON.—Mayari iron, says *Canadian Machinery*, is a low phosphorus and low sulphur iron, containing besides the elements ordinarily found in iron, nickel, chromium and a small percentage of vanadium and titanium. Unlike other alloys, this iron is a natural product, the elements being mixed in the native ore and not added in the smelting. According to the Bethlehem Steel Company, this iron has been found to give greatly increased strength to steel castings, a better surface, reduction of spongy spots and segregation, and longer life when subjected to heat and wear.

THE JAPANESE EARTHQUAKE.—According to *The Iron Age*, New York, revised figures of the Japanese disaster show that the reconstruction effort need not be so great as was at first feared. Figures placed the total loss at 915,000,000 dols., of which about 80 per cent. will be largely recoverable by the expenditure of effort or work, rather than investment in raw material. The figure indicated, divided by the population of Japan proper, shows a loss of approximately 16 dols. per inhabitant. This is but a fraction of the *per capita* taxes in Great Britain for the current year, and may be compared with the total annual tax bill of the American people, which is nearly 100 dols. per person. We may here state that the Chancellor of the Exchequer, on February 23 last, said the taxes per head of population were, in the United Kingdom, 10*l.* 10*s.* direct and 6*l.* 2*s.* indirect; and in the United States 13·60 dols. direct and 12·70 dols. indirect. In another part of the same issue, our contemporary reports that the immense amount of rebuilding now under way in Japan makes that country the prize market for exporters of building material in particular, and advocates greater activity on the part of American exporting firms.